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APPENDIX 21

SYSTEMATIC ASSESSMENT OF PROTECTIVE CLOTHING FOR ALBERTA WORKERS

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Final Research Project Report
Prepared for
Alberta Occupational Health and Safety
Heritage Grant Program

by

E.M. Crown, K.B. Rigakis and J.D. Dale

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APPENDIX 21

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APPENDIX 21

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Note: The contents of this volume represent the contents of a computerized literature file as of June 15, 1989. Updated searches may be conducted on any of the keywords listed.

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KEYWORDS

1 ARAMID (NOMEX, KEVLAR)
2 ASBESTOS
3 BEHAVIOUR AND ATTITUDES
4 BLENDS
49 BODY TEMPERATURE MEASUREMENT
5 BREATHING APPARATUS
6 BURN INJURY
7 CHEMICAL RESISTANCE
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ABSTRACTS

Ajzen, I. & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, N.J.: Prentice Hall Inc..

Keywords: 3
BEHAVIOUR AND ATTITUDES,

(NO Copy on file)

Abstract:

Alkidas, A. & others (1971). Study of hazards from burning apparel and the relation of hazards to test methods, report no. 1. Atlanta, Ga.: Georgia Inst. of Technology.

Keywords: 4,6,10,15,18,40,
BLENDS, BURN INJURY, COTTON, FABRIC IGNITION TIME, FLAMMABILITY, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
The following thermal properties of a selected set of cotton, nylon, polyester, acetate and blend fabrics were measured: thermal conductance, specific heat, ignition or melting temperature, infrared reflectance and transmittance, activation energy, reaction enthalpy and ignition time under radiative fabric heating. Detailed distributed-parameter ignition models and simplified analysis based on groups established which govern the heating and reaction processes. Experimental and theoretical results were compared.

Alkidas, A. & others (1972). The study of hazards from burning apparel and the relation of hazards to test methods. report no. 2. Atlanta, Ga.: Georgia Inst. of Technology.

Keywords: 4,6,10,15,18
BLENDS, BURN INJURY, COTTON, FABRIC IGNITION TIME, FLAMMABILITY,

(Copy on file)

Abstract:
The following properties were measured on ten typical apparel fabrics: thermal conductance, specific heat, auto ignition, temperature, optical properties of original and charred fabrics, reaction kinetic parameters (by thermogravimetric methods), reaction enthalpies, ignition times in radiative and flame environments. A detailed, lumped-parameter modelling analysis of the probability of ignition was developed.

Abbott, N.J.. (1973). The flammability of coated apparel fabrics.. *Journal of Coated Fabrics*, 3(10), 135-141.

Keywords: 14,18,
FABRIC CONSTRUCTION, FLAMMABILITY,

(NO Copy on file)

Abstract:

Abbott, N.J., Schulmann, S., Schoppee, M.M. (1976). Heat resistant and nonflammable materials. *AFML-TR-76-47, Annual Report of Work Done During Contract F33615-75-C-5168.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Abbott, N.J. & Schulman, S. (1976). Protection from fire: nonflammable clothing - a review. *Fire Technology*, 12, 205 - 218.

Keywords: 6,43,18,21,23,24,14,11,28,
BURN INJURY, THERMAL PROTECTION, FLAMMABILITY, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES, FABRIC CONSTRUCTION, DURABILITY OF F R FIBERS, METALLIZED FABRICS,

(Copy on file)

Abstract:
Fire environment. burn injury, fibers for nonflammable clothing, thermal protection and garment design are discussed.

Protection requires that clothing does not ignite and the insulating values of the clothing be sufficient that the amount of heat transferred through the clothing not be enough to cause serious burn damage for the time exposed.

Heat flow through the fabric is determined by fabric thickness and porosity. A thicker fabric gives better insulation, a more porous fabric allows more heat to flow through the structure (both a part of fabric weight).

Air is a very good insulator, therefore, many fabric layers of either separate garments or fiber batts provide many air spaces for protection.

Shrinkage reduces the thickness of the air layers which reduces the insulative value of the clothing. Thermal shrinkage depends on the fiber properties and of its temperature which depends on the heat flux to which the fabric is exposed, the time of exposure and the fabric's ability to reflect infrared radiation. A highly reflective aluminum coating is often added to the garment surface of firefighters' clothing to extend the time to which the wearer can be exposed to radiation.

The reflective coatings tend to make the garment heavy, bulky and stiff reducing mobility and long-term comfort.

Burn damage is greatest if the intensity high and the time short, therefore, multiple layers reduce or eliminate the direct transmission of heat through the system and the increased fabric mass spreads the heat load over a longer time reducing the maximum temperature reached by the skin.

Abbott, N.J. & Schulman, S. (1976). Protection from fire: nonflammable fabrics and coatings. *Journal of Coated Fabrics*, 6, 48 - 64.

Keywords: 43,18,17,21,23,24,14,11,12,
THERMAL PROTECTION, FLAMMABILITY, FIREFIGHTERS' PROTECTIVE CLOTHING, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES, FABRIC CONSTRUCTION, DURABILITY OF F R FIBERS, F R FINISHES,

(NO Copy on file)

Abstract:
Article concerned with types of currently available materials which are potentially suitable for firefighters protective clothing and discusses some of the principles on which the design of such clothing must be based.

Turnout coat used during 'ordinary' conditions - consists of water impermeable layer and insulating layer to protect from burns and will minimize heat stress.

Proximity suit used in emergency situations of high heat flux and temperature the material must not burn, must insulate effectively and resist mechanical damage, not restrict movements or cause discomfort.

Most useful are fibers having a LOI value of 25 - 30.

Need protection against radiant heat - can control the number of layers, the total mass of the fabric within limits which the wearer can tolerate, the reflectance particularly of the outer surface, which can be varied with the addition of a coating. However, few coating materials are suitable as they must be nonflammable, have infrared reflectance > 75%, resist penetration by water and steam, have good resistance to abrasion, flexing, chemicals and soiling, be easy to clean and fast drying, highly visible in smoke or low levels of illumination, be comfortable - light, flexible, permeable to vapour as well as being suitable to application to fabrics.

Thermal shrinkage can be controlled by a stabilizer or by blending shrinkable fibers with a relatively stable fiber.

Insulation from convective or conductive heat depends upon fabric thickness. Radiative insulation depends on fabric weight (thickness and porosity). Total heat transfer depends not only on weight but shrinkage or changes in absorption due to darkening.

Fabric integrity also important.

Abbott, N.J. et, al. (1976). Protection from fire: firefighters proximity suit. *AATCC Symposium: Coated Fabrics Update.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Abbott, N.J. (1977). Nonflammable fibers: their properties, availability, and potential for apparel. *Proceedings of the Eleventh Annual Meeting, Information Council on Fabric Flammability*, 150 - 161.

Keywords: 43,1,35,10,12,15,18,23,30,32,33,42,
THERMAL PROTECTION, ARAMID (NOMEX, KEVLAR),
PHYSICAL PROPERTIES OF F R FIBERS, COTTON, F R FINISHES,
FABRIC IGNITION TIME, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
MISCELLANEOUS F R FIBERS, NOVOLOID (KYNOL), PBI,
THERMAL PROPERTIES OF F R FIBRES,

(NO Copy on file)

Abstract:

Clothing to protect against burn injury when exposed to heat and flame must not ignite or transfer too much heat to the body. The clothing must provide protection until the wearer is away from the danger by remaining intact.

Common flame-resistant fibers have a LOI between 25 and 30.

Three groups of fire conditions: 1) routine: heat flux levels and air temperatures of small fires, 2) ordinary: room fire, 3)emergency: flash fire

Study examined the ignition of some flame-resistant fabrics when exposed to thermal radiation. It was initiated to determine the rate of loss of mechanical properties of the fabrics under radiation conditions of a large fire. Studied were cotton, Nomex, Durette, Kynol, HT-4, PBI.

Loss in Strength - except PBI the differences were small. The high moisture regain and slow rate of oxidative degradation below 400 C provide a time delay for the loss of strength of PBI. The loss of tear strength for Nomex and HT-4 was less than that of tensile strength (radiant).

Ignition: Untreated cotton ignited after one minute at 350 C, Nomex, Durette and HT-4 at 550-600 C and Kynol and PBI, 500 C. At higher heat flux cotton, Kynol and Nomex had similar ignition times and PBI, Durette, HT-4 took 5 - 10 times as long to ignite as the others. Increased fabric weight delays ignition due to mass heating effect but doesn't after the minimum heat flux which causes spontaneous ignition. Application of a FR treatment increases the min. temp. required. Values specific only to these test conditions.

Inherently flame retardant fibers are hard to dye and have poor lightfastness because the natural colour darkens quickly on exposure to light.

One pound of staple fiber costs 5 - 10 times as much as common apparel textile fibers.

Andreen, J.H., Gibson, J.W. & Wetmore, O.C. (1953). Fabric evaluations based on physiological measurements of comfort. *Textile Research Journal*, 23, 11 - 23.

Keywords: 9,10,41,47
COMFORT ASSESSMENT, COTTON, THERMAL / HEAT STRESS, WEARING COMFORT,

(NO Copy on file)

Abstract:
Physiological factors such as body surface temperature, electrical conductivity of the skin, rate of sweating, total sweat cost and heart rate were measured as criteria for evaluating in warm and hot environments the comfort afforded human test subjects by textile apparel. To correlate the physiological parameters with individual impressions of comfort and to assess the contributing physiological factors, expressions of subjective opinion of the different fabrics were solicited.

Tested: 80/20 wool/Orlon acrylic fiber, cotton shirting, filament nylon shirting, cotton denim, spun nylon denim, Neoprene-coated nylon

Anon (0000). Literature survey of burn injury potential of conventional wearing apparel.. Source unknown.

Keywords: 6,8
BURN INJURY, CLOTHING SYSTEMS,

(Copy on file)

Abstract:

Anon (1970). Specifications for clothing for protection against intense heat for short periods. British Standards Institution, BS 3791, 2 - 28.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1971). Standard on protective clothing for structural fire fighting. *NFPA* (1981 Edition).

Keywords: 37,17,8,45,21,14,16,18,43
REGULATIONS AND STANDARDS, FIREFIGHTERS' PROTECTIVE CLOTHING, CLOTHING SYSTEMS, VAPOUR BARRIERS, GARMENT DESIGN, FABRIC CONSTRUCTION, FABRIC SYSTEMS, FLAMMABILITY, THERMAL PROTECTION,

(Copy on file)

Abstract:
Temperature extremes, steam, hot water, hot particles, corrosive substances.

Flame resistant, durable, lightweight, water resistant, non-irritating to skin, cleanable.

Minimum interference to physical movement, use of firefighting tools, protective breathing apparatus

Design: Air circulation - cooling - use of spacers, billowing design at bottom of coat, air inlets (under arm and shoulder area) - belts increase heat storage; Impact resistance - upper extremities - use of padding -shouldn't add excess weight - fatigue, heart problems; Padding - elbow protection for wear resistance and heat protection when crawling.

Outer surfaces of fasteners must be non-ferrous to prevent sparking.

Anon (1971). Standard on protective clothing for structural fire fighting. NFPA.

Keywords: 47,37,18,23,43,21,
WEARING COMFORT, REGULATIONS AND STANDARDS, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, GARMENT DESIGN,

(Copy on file)

Abstract:

Anon (1971). Suited up to beat the heat. *Chem. Week*, 108(22), 47 - 48.

Keywords: 43,23,18,29,
THERMAL PROTECTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, MILITARY PROTECTIVE CLOTHING,

(Copy on file)

Abstract:
Racing has put glamor into fire-safety fabric sales, but bigger markets are developing for military, industrial work clothes.

Anon (1972). Criteria for a recommended standard...occupational exposure to hot environments. Washington, D.C.: U.S. Department of Health, Education and Welfare, National Institute for Occupational Safety and Health.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1973). Clothing for protection against heat and fire - general recommendations for users and those in charge of such users. *International Organization for Standardization*, 150 2801-1973.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1973). Rapid method of identifying flame retardant fibers and finishes in fabrics. *Textile Chemist and Colorist*, 5(12), 30 - 35.

Keywords: 40,18,
TESTING AND TEST METHODS, FLAMMABILITY,

(Copy on file)

Abstract:
Shown that flame retardant fibers, fiber additives and finishes in fabrics can be identified by their infrared spectra.

The rapid and nondestructive multiple internal reflection technique was found to be suitable for the identification of most inherently flame retardant fibers. If the fabric has an open, coarse surface, the MIR spectrum may be of weak intensity, but it will be sufficient for identifying the fiber present in the fabric.

A rapid solvent extraction procedure requiring about 1 minute was used for identifying flame retardant fiber additives and finishes in fabrics. The fabric sample was placed on a KRS-5 crystal, 1 - 2 mL of a suitable solvent was added and the fabric removed after 30 seconds. After the solvent evaporated from the crystal, an infrared spectrum of the residual thin film was obtained by the MIR procedure. Infrared spectra were obtained for 14 flame retardant fibers and finishes in fabrics. These spectra can serve as references for future analyses.

As additional flame retardant fibers and finishes become commercially available, their infrared spectra can be obtained by these techniques and added to the present file.

Anon (1973). The Jim Clark foundation fire resistant clothing supplement. London: Jim Clark Foundation.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1973). Wool has helped them win many a rally. *Goul Vag 3*: 4, 8.

Keywords: 13,18,47
F R WOOL (ZIRPRO), FLAMMABILITY, WEARING COMFORT,

(NO Copy on file)

Abstract:
Two rally drivers wear wool because of comfort and natural flame resistance.

Anon (1974). Recommendations for a standard for work in hot environments. Washington, D.C.: Standards Advisory Committee on Heat Stress, Draft 5, Department of Labour.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1974). Recommendations for a standard for work in hot environments. *Bureau of National Affairs' Occupational Safety and Health Reporter*, 3(22), 1055.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1976). New fabric for firefighters. *DuPont Magazine*, 70, 10 - 11.

Keywords: 18,1,10,23,11,6,14,43,17,
FLAMMABILITY, ARAMID (NOMEX, KEVLAR), COTTON,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
DURABILITY OF F R FIBERS, BURN INJURY, FABRIC CONSTRUCTION,
THERMAL PROTECTION, FIREFIGHTERS' PROTECTIVE CLOTHING,

(Copy on file)

Abstract:
Nomex III - tough, reliable apparel fabric; provides extra margin of ì protection against flame and intense heat; protective properties don't wash ì out or wear out; better feel and appearance than other types of Nomex fiber; ì will isolate and insulate wearer for as long as possible in direct flame ì exposure or high energy heat sources; higher thermal stability than other ì Nomex fibres; protects against second degree burns 50% longer than FR cotton ì of the same weight and fabric construction; available in many weights from ì lightweight shirt fabrics to heavyweight industrial duck fabrics.

Anon (1977). Fire and personal protection. *National Safety News*, (Nov.), 62 - 64.

Keywords: 43,18,26,2,23,31,20,28,22,36,13,11,35
THERMAL PROTECTION, FLAMMABILITY, LEATHER, ASBESTOS, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), MOLTEN METAL EXPOSURE, FOUNDRY WORKERS' PROTECTIVE CLOTHING, METALLIZED FABRICS, GLOVES, PROTECTIVE FOOTWEAR, F R WOOL (ZIRPRO), DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS,

(Copy on file)

Abstract:
Traditionally, leather and asbestos provided the protection against heat, sparks, fire of low intensity. Leather also protects against the hazards of hot splashes, limited impact forces, infrared and ultra-violet radiation.

Protective garments should be free of turned up cuffs and other projections which could catch and retain hot metal, sparks, etc. Pockets should have flaps which can be fastened shut.

Asbestos and sometimes wool can be used for protection against hot metal, radiant heat and flame hazards of somewhat higher intensity.

Foundrymen's leggings should completely encircle the leg from knee to ankle and have a flare at the bottom to protect the instep. The design of the legging and fastenings should permit quick removal.

Clothing of reflectorized fabrics are essential where extremely high ambient temperatures must be faced. The outer coating reflects away most of the radiant heat and liner insulates against the rest and acts as a vapor barrier.

Firefighters exposed to flame, extreme heat, frostbite, fatigue, excessive perspiration, unpredictable impact, situations that can deteriorate rapidly calling for quick mobility, becoming obscure by smoke from potential rescuers, etc.

Protective clothing must be reasonably economical, reasonably long-wearing and easy to put on in a hurry.

Turnout coat - outer shell - flame-resistant synthetic fiber that acts as a heat reflector and barrier; removable liner - acts as vapor barrier, an insulating batting and a lining fabric. The air spaces between layers offer further insulation against heat.

Gloves should be resistant to cut, puncture, heat penetration, wet heat penetration, cold, electricity, liquids and flame, as well as be comfortable, visible, durable, dryable and not impede dexterity.

Footwear - steel toe cap, steel insoles, optional lengths, good traction on ladders, wet surfaces, pitched roofs and mountainsides, lightweight, less cumbersome and less prone to lead to fungal infection.

Anon (1977). Proposed test method for thermal protective clothing. *ASTM Designations* D-13-77-4.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1979). New nomex wins fire-pit tests, becomes government standard. *Textile Week*, 5(31), 1.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1979). Rayon inner layer for flame-retardant gloves. *Nonwovens Report International*(103), 9.

Keywords: 43,30,22,18,1,14
THERMAL PROTECTION, MISCELLANEOUS F R FIBERS, GLOVES, FLAMMABILITY, ARAMID (NOMEX, KEVLAR), FABRIC CONSTRUCTION,

(NO Copy on file)

Abstract:
Flame-retardant viscose rayon staple produced by Lenzing, Austria, is now being used as a needled inner surface for protective gloves based on DuPont's Nomex aramid flame-resistant fibres. The viscose rayon fibres contain no halogens and do not form droplets during exposure to heat.

Anon (1979). Wool to protect british steel workers. *Golden Fleece*, 8(21).

Keywords:

(Copy NEVER VIEWED)

Abstract:
Lightweight Zirpro-treated flame-retardant wool gabardine suits are protecting British steel workers from flame and heat.

Anon (1980). Protective clothing. *Federal Register*, 45(179), 60676 - 60680.

Keywords: 21,43
GARMENT DESIGN, THERMAL PROTECTION,

(Copy on file)

Abstract:

Anon (1981). Evaluation of protective clothing. *CSIRO Textile News*, 10(8).

Keywords: 42,6,41,17,35,43,23,18
THERMAL PROPERTIES OF F R FIBRES, BURN INJURY, THERMAL / HEAT STRESS, FIREFIGHTERS' PROTECTIVE CLOTHING, PHYSICAL PROPERTIES OF F R FIBERS, THERMAL PROTECTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY,

(NO Copy on file)

Abstract:
The properties of various textile fabrics that influence their thermal behaviour and how these could minimize danger from burn injury and heat exhaustion during fire fighting are discussed.

Anon (1981). Heat transfer characteristics of flight jacket materials. *Textile Flammability Digest* (3).

Keywords: 43,18,29,40,1,32,6,23,24
THERMAL PROTECTION, FLAMMABILITY, MILITARY PROTECTIVE CLOTHING, TESTING AND TEST METHODS, ARAMID (NOMEX, KEVLAR), NOVOLOID (KYNOL), BURN INJURY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES,

(NO Copy on file)

Abstract:
Describes apparatus and procedures for testing flight jacket materials for cold weather and flame resistance developed at Wright-Patterson Air Force Base. Combination of Nomex fabric as the outer shell and Kynol batting as insulation proved superior to all other combinations in cold weather or moderately cold weather jackets to protect air crew personnel from heat transfer and burn damage when exposed to a jet fuel fire.

Anon (1981). Industrial trial on wool protective clothing. *Textile Digest* (Oct.).

Keywords: 13, 12, 10,
F R WOOL (ZIRPRO), F R FINISHES, COTTON,

(NO Copy on file)

Abstract:
Flame-resistant Zirpro-treated wool fabrics were found to be better for protective clothing than traditional cotton fabrics. Trials of the fabrics were conducted at a ship refitting yard where workers gave them an enthusiastic welcome.

Anon (1981). Third annual natural fibers conference. *Textile Research Journal*, 3, 123.

Keywords: 10,31,18,23,
COTTON, MOLTEN METAL EXPOSURE, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(NO Copy on file)

Abstract:
Complete texts of 13 papers presented September 17 - 19 cover various aspects i of cotton fiber washing, production of closed-boll cotton, the micro-processor i system; also, clothing fabrics protective against molten metal hazards and i convective heat (open-flame) hazards, and smoldering characteristics of cotton i upholstery fabrics.

Anon (1982). Compilation of fire test standards. First Edition / 1982, Sponsored by ASTM Committee E-5 on Fire Standards, published 1982, 676.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Anon (1982). Greater protection for foundry workers. *High Performance Textiles*, 2, 3.

Keywords:

(Copy NEVER VIEWED)

Abstract:

A brief description is provided of a new protective clothing glass fiber fabric of 2000 g/m super 2 made using bulked filament E glass. The fabric possesses a finish which does not swell but forms a protective char when subjected to molten metal splash.

Anon (1982). In the hand...safely. *High Performance Textiles*, 2, 13.

Keywords:

(Copy NEVER VIEWED)

Abstract:

A new safety glove made in France from DuPont's Kevlar, that can double the protection time against high temperatures of molten aluminum, is described.

Anon (1982). Materials and material assemblies used in clothing for protection against heat and flame - part 1. specification for flammability testing and performance. London, U.K.: British Standards Institution.

eywords:

(Copy NEVER VIEWED)

bstract:
The performance requirements are specified for the flame spread properties of materials and material assemblies for use in protective clothing when tested by the methods detailed in BS 5438 modified as given in Appendix A of this standard and using, where appropriate, a cleansing or wetting procedure detailed in BS 5651. Classifications for flammability and durability to cleansing indices are included.

Anon (1982). Progress in fire safety: regulations, polymers, chemicals, markets. Lancaster PA: Technomic Publishing Company, Inc.

eywords: 18,37,43
FLAMMABILITY, REGULATIONS AND STANDARDS, THERMAL PROTECTION,

(Copy on file)

ostract:

Anon (1982). Protective clothing. Manchester, UK, (Shirley Publication S45). SBN 0-903669-41-2.

eywords: 21,
GARMENT DESIGN,

(NO Copy on file)

ostract:
The texts of the 10 papers presented at a conference on 21 October 1982 are reproduced. The papers are abstracted individually in World Textile Abstracts, 1983, No. 11.

Anon (1984). Flame-resistant cloth provides up to three minutes of protection. *Japan Economic Journal*, 22(1117), 16.

Keywords:

(Copy NEVER VIEWED)

Abstract:
New flame-resistant clothing from Teikoku Sen-i Company is described. Made of "Pyke" brand fiber produced from aramid and carbonized fibers, the clothing protects the user for three minutes from 1300C heat.

Anon (1984). Protective clothing for farm welders. Alberta Agriculture, Home Economics Branch.

Keywords: 43,48,31,21,23,18,
THERMAL PROTECTION, WELDERS' PROTECTIVE CLOTHING, MOLTEN METAL EXPOSURE, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY,

(Copy on file)

Abstract:

Anon (1984). Protective clothing for metal workers. *High Performance Textiles*, 4(9), 10.

Keywords: 31,40,37,43
MOLTEN METAL EXPOSURE, TESTING AND TEST METHODS, REGULATIONS AND STANDARDS, THERMAL PROTECTION,

(Copy on file)

Abstract:
Discussed are new methods for evaluating clothing fabrics likely to be exposed to molten metals, as proposed by the ASTM committee on protective clothing.

Anon (1984). Textile fabrics - burning behaviour - measurement of flame spread properties of vertically oriented specimens. Geneva, Switzerland: International Standards Organization.

Keywords: 37,40,18
REGULATIONS AND STANDARDS, TESTING AND TEST METHODS, FLAMMABILITY,

(NO Copy on file)

Abstract:
This international standard specifies a method for the measurement of flame spread properties of vertically oriented textile fabrics intended for apparel, curtains, and draperies in the form of single or multi-component (coated, quilted, multi-layered, sandwich construction and similar combinations) fabrics.

Anon (1985). Electronics in flammability test. *Textile Horizons* (Jan.).

Keywords: 18,40,
FLAMMABILITY, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Anon (1985). Fire study. *Textile Horizons*, (May), 17.

Keywords: 40,6,18,
TESTING AND TEST METHODS, BURN INJURY, FLAMMABILITY,

(Copy on file)

Abstract:

Anon (1985). Tyvek protects in overalls. *Textile Horizons*, (Jan.).

Keywords: 2,34
ASBESTOS, PESTICIDE PROTECTIVE CLOTHING,

(Copy on file)

Abstract:

Anon (1986). FR fibers: the european scene. *Textile Horizons*, (June), 33 - 35.

Keywords: 18,33,30,1,
FLAMMABILITY, PBI, MISCELLANEOUS F R FIBERS, ARAMID (NOMEX, KEVLAR),

(NO Copy on file)

Abstract:

Public awareness of the dangers of burning textiles (or burning foam covered by textiles) as well as government and public body moves to improve safety standards is leading to an increasing demand for fire-resistant textiles. The majority of outlets for such products will fall into one of the following sectors: the contract sector, for example, hospitals, hotels, and theatres;the transport sector, (ie) the armed forces, fire brigades and blast furnace workers.

How well are the West European man-made fibre producers reponding to the challenge? Stan Davies looks at the complex nature of this area of textiles and describes some of the specialty products being produced today by the man-made fibre industry.

This article examines the complex nature of flammability in relation to the ignition performance and Limiting Oxygen Index (LOI measured by ASTM 2863) of manmade fibers such as Trevira CS, Danufil CS, PBI, Viscose FR, Velicren FR, Kermel, Kevlar and its rival Twaron, Teklan, Inides and Asgard, all of which are now being produced in the European market. Details of the fiber dimensions and end uses are also given.

Anon. ( ). Seminar: 'Firefighters clothing and heat protection'.. *CSIRO Textile News*

Keywords:

(Copy on file)

Abstract:
A seminar on 'firefighters Clothing and Heat Protection' was held at the Division of Textile Physics, Ryde, last year. Delegates from all over Australia included firemen, garment manufacturers, fibre and fabric suppliers, and researchers in this area.

This issue of CSIRO Textile News includes a report on all the papers, which i covered the basics of heat transfer through textiles, clothing physiology, i evaluation of protective clothing, the influence of finishes, flame-retardant i treatments and standards and tests.

Anon (19xx). Flame-Retardant clothing. *Textile Manufacturer*, 79(3), 21.

Keywords: 43,23,13,18,16,1,6
THERMAL PROTECTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), F R WOOL (ZIRPRO), FLAMMABILITY, FABRIC SYSTEMS, ARAMID (NOMEX, KEVLAR), BURN INJURY,

(NO Copy on file)

Abstract:
Int. Wool Secretariat reports that protective clothing of flame-retardant wool "assemblies" gives better protection against convective heat from flames than other commercial FR fabric combinations of similar weight and construction. It is also claimed that wool gives the "longest pain/blister alarm time". Claims are based on evluations of the thermal protection afforded by two-layer assemblies of wool, synthetics and blended fabrics. Seven FR outerwear woven fabrics evaluated in various combinations with a second layer of the same fabric as well as the six knitted fabrics, five of them wool and one aramid. Details given on test procedures and determination of time required for sufficient energy to produce a first (pain) and second (blister) degree burn.

Anon (19xx). Zirpro flame-retardant wool furnishings and protective clothing. *International Wool Secretariat.*

Keywords: 13,18,12,37,31,24,6,23,43,41
F R WOOL (ZIRPRO), FLAMMABILITY, F R FINISHES, REGULATIONS AND STANDARDS, MOLTEN METAL EXPOSURE, INSULATIVE PROPERTIES, BURN INJURY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, THERMAL / HEAT STRESS,

(NO Copy on file)

Abstract:
Wool can pass all the major flammability standards for textiles, performs better than synthetics on safety specifications such as resistance to heat and molten metal splashes, it is cost effective, wears well, keeps its appearance, resists soiling and is easy to clean.

Wool is naturally flame retardant to a high degree, it may smoulder and char but does not burst into flame. It doesn't melt and drip but forms an insulating char. It doesn't shrink during burning.

Zirpro treatments allow wool textiles to meet the most severe flammability regulations. The treatment is simple, inexpensive and does not affect the handle, soil resistance, strength, abrasion resistance, colourfastness or air-permeability. The treatment is compatible with shrink-resistant, mothproofing and other easy-care treatments.

Zirpro FR treatments make it possible to obtain adequate protection from lightweight wools.

Flame retardance alone is not proof that a fabric is suitable for protection against heat transfer from convective heat. Zirpro wool was compared with novoloid, FR rayon, aramid, FR cotton fabrics and it was found that Zirpro wool had less then half the temp. rise recorded for the other fabrics as well as the longest pain alarm time - the interval between the onset of pain and the incidence of a second degree burn as indicated by a blister. It offers time to move away from heat and flame before serious burns occur. Heat capacity is such that it is cool to touch when removed from flame.

Metal workers need protection from high temperatures, heat radiation, flames, flying sparks and molten metal. Tests show wool offers best protection: unique metal shedding properties over FR cotton, modacrylic/glass, aramid, novoloid and asbestos.

Wool often chosen for firefighters as it alleviates heat stress and has high thermal insulation to protect against cold. Vigorous activity produces perspiration which passes through air spaces in fabric and through fibre absorption and diffusion which increases total perspiration transfer.

Anon. (1982). *The govmark book on flammability standards and flammability test methods of textiles, plastics and other materials used in home and contract furnishings.*. Bellmore, N.Y.: The Govmark Organization, Inc..

Keywords: 18,40,37
FLAMMABILITY, TESTING AND TEST METHODS, REGULATIONS AND STANDARDS,

(NO Copy on file)

Abstract:
This volume is intended as a guide to the complex problems arising from the large number of government agencies and jurisdictions which have authority for test methods and standards relating to the flammability of contract and home furnishings.

the book begins with clear distinctions among the requirements by occupancy; i.e., apartments, places of public assembly, motels, mercantile, penal, etc. It then proceeds to discuss these individual requirements with abstracts and appropriate sketches, frouped by Building code and Federal Standards, Local Jurisdictions, Voluntary Industry Standards and Future Flammability Standards and Test Methods.

Test methods and standards come from ASTM(6), Federal Agencies(7), NFPA(3), FAA(1), CPAI(2), NBS(1), California, boston and New York. As one would expect, the state of California is the star of the "Local Jurisdictions," occupying 28 of the 41 pages (68%) of that chapter.

This book is probably not for the general reader, but those who are involved in fabric flammability should find sufficient value to offset the purchase price. The abstracts and sketches are clear and concise and should be of enormous help to anyone lost in the briar patch of flammability regulations.

Anon. (1983). Dress right for safety: general body protection.. *National Safety News*, 127(3), 54-57

Keywords: 8
CLOTHING SYSTEMS,

(NO Copy on file)

Abstract:

Astrand, P.O. & Rodahl, K. (1977). Chapter fifteen - temperature regulation. In P.O. Astrand and K. Rodahl's *Textbook of Work Physiology*. New York: McGraw Hill, 491 - 536.

Keywords: 41,47,
THERMAL / HEAT STRESS, WEARING COMFORT,

(Copy on file)

Abstract:
CONTENTS
Heat Balance; Methods of Assessing Heat Balance; Magnitude of Metabolic Rate; Effect of Climate - Cold, Heat; Effect of Work; Temperature Regulation; Acclimatization - Heat, Cold; Limits of Tolerance - Normal Climate, Failure to Tolerate Heat; Upper Limit of Temperature Tolerance - Age, Sex, State of Training; Coordinated Movements; Mental Work Capacity; Water Balance - Normal Water Loss, Thirst, Water Deficit; Practical Application - Physical Work, Warm-Up, Radiation, Air Motion, Clothing, Microclimate.

Astrand, P.O. & Rodahl, K. (1977). Textbook of Work Physiology. New York: McGraw Hill.

Keywords: 9,41,47,
COMFORT ASSESSMENT, THERMAL / HEAT STRESS, WEARING COMFORT,

(NO Copy on file)

Abstract:
CONTENTS
Chapter One - The Body at Work
Chapter Two - Energy Liberation and Transfer
Chapter Three - Muscle Contraction
Chapter Four - Neuromuscular Function
Chapter Five - Blood and Body Fluids
Chapter Six - Circulation
Chapter Seven - Respiration
Chapter Eight - Skeletal System
Chapter Nine - Physical Work Capacity
Chapter Ten - Body Dimensions and Muscular Work
Chapter Eleven - Evaluation of Physical Work Capacity on the Basis of Tests
Chapter Twelve - Physical Training
Chapter Thirteen - Energy Cost of Various Activities
Chapter Fourteen - Nutrition and Physical Performance
Chapter Fifteen - Temperature Regulation
Chapter Sixteen - Physiology of Various Sport Activities
Chapter Seventeen - Factors Affecting Performance
Chapter Eighteen - Health and Fitness

Attia, M., Engel, P. & Hildebrandt., G. (1979). Quantification of thermal comfort parameters using a behavioral indicator. *Physiology and Behavior*, 24, 901 - 909.

Keywords: 3,9,24,41,43,47,
BEHAVIOUR AND ATTITUDES, COMFORT ASSESSMENT, INSULATIVE PROPERTIES, THERMAL / HEAT STRESS, THERMAL PROTECTION, WEARING COMFORT,

(Copy on file)

Abstract:
This study is a pilot attempt to propose an alternative approach to the question of working in hot or cold ambient atmospheres. Thermal alliesthesial responses were used to calibrate the thermal characteristics of man undergoing exogenous and/or endogenous thermal loads. Ambient thermal conditions, activity levels, clothing (CLO-values), exposure durations, core or mean skin temperatures associated with thermal comfort were estimated for five subjects at six different room temperatures. One practical field application in the steel industry is discussed. The results indicate that the present method is most suited for the optimization of work/rest regimens during industrial excessive heat exposures when the improvement of thermal environment is not possible or economically not feasible.

Audet, N.F. (1982). U.S. navy battle dress program. *In Progress in Fire Safety: Regulations, Polymers, Chemicals, Markets* (pp. 195 - 217). Lancaster, PA: Technomic Publishing Company Inc.

Keywords: 23,1,6,7,10,11,12,13,18,29,30,3,40,42,43,47
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), ARAMID (NOMEX, KEVLAR), BURN INJURY, CHEMICAL RESISTANCE, COTTON, DURABILITY OF F R FIBERS, F R FINISHES, F R WOOL (ZIRPRO), FLAMMABILITY, MILITARY PROTECTIVE CLOTHING, MISCELLANEOUS F R FIBERS, BEHAVIOUR AND ATTITUDES, TESTING AND TEST METHODS, THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION, WEARING COMFORT,

(Copy on file)

Abstract:

The Navy Clothing and Textiles Research Facility (NCTRF) is presently engaged in the development of several fire retardant shipboard clothing items for the Personnel Protection Branch (PPB), Damage Control and Personnel Protection Division, Naval Sea System Command (NAVSEASYSCOM). Articles of clothing previously or currently being developed under this program include utility, firefighting, chemical warfare and anti-exposure clothing. Other products requiring fire retardancy being developed by other navy activities for the SPPO including ballistic helmets and vests, and floatation jackets. These programs have resulted from the implementation of findings and recommendations of a chief of Naval Operations (CNO) Ad Hoc Study Group formed to study personnel hazards existing aboard ship. The group concluded that major threats to personnel were fire, fragments and man-overboard and recommended improved Battle Dress to provide the needed protection. Of the threats defined, fire was considered the prime threat because it can be encountered during normal operations as well as being supplemental to other threats during combat conditions.

Clothing developments to date have ailminated with the introduction of a lightweight Nomex fire retardant coverall for personnel working in engineering spaces and performing hot work aboard ship, and the near completion of a development program for a fire retardant utility uniform for all shipboard personnel. This report provides information on all current program developments.

This paper includes a discussion of fire retardant materials, the types of testing performed to evaluate the products being developed, and the current status of the NCTRF Battle Dress Programs.

Materials being used in the Battle Dress Program: FRT cotton (THPOH/NH3), FRT wool (Zirpro = TBPA - K2ZrF6), PFR Rayon (Poly (n-propoxyphospazene)), Nomex/Kevlar.

Material Selection Factors: degree of fire retardancy, melt characteristics, thermal shrinkage, burn protection, comfort, color selection, appearance, durability, launderability, user acceptance, cost.

Material Evaluation Criteria: breaking strength, tear strength, air permeability, thickness, dimensional stability, color fastness, vertical flammability (new and after 50 shipboard launderings), burn protection time (flame impingement), inhalation toxicity.

Garment Evaluations: physiological, fire pit, shipboard user trials.

Bailey, M. (1977). Improved crash crew rescue fire fighters' boots - a feasability study. *Fire Technology*, 13(4), 329 - 338.

Keywords: 18,36,11,28,1,2,23,17,43,
FLAMMABILITY, PROTECTIVE FOOTWEAR, DURABILITY OF F R FIBERS,
METALLIZED FABRICS, ARAMID (NOMEX, KEVLAR), ASBESTOS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
FIREFIGHTERS' PROTECTIVE CLOTHING, THERMAL PROTECTION,

(NO Copy on file)

Abstract:
Since most boots are made of rubber, various types of elastomers were surveyed to determine if any could significantly improve heat aging and protective qualities of firefighters' boots. Found commercial elastomers satisfactory so no need for expensive high heat resistant fluorocarbons in boots.

Reflective materials - advantage of aluminized Nomex fabrics is that they are lighter and more flexible than aluminized asbestos but less resistant to severe prolonged doses of high radiant heat. - found value of reflective coating as part of boot low as the effect would be quickly reduced by soiling. Certain extinguishing agents and abrasion - in the form of spats or leggings over insulated boots, superior heat protection could be provided and, when they were soiled or damaged, they could easily be replaced.

Specimens were cut from standard and insulated boots and aluminized knitted Nomex was bonded to one set of specimens which were then tested for heat transmission. The aluminized boot specimens transferred less heat over a short time interval, were more slowly degraded, withstood smoking, blistering and surface degradation for a longer period than did the others.

Conclusions: (p. 337)
- it is feasible to adopt insulated commercial firefighters' boots for use with crash crew firefighters' protective clothing
- when extreme heat or fire entry conditions are encountered, reflective spats or leggings can be used to protect both the firefighter and the footwear.
- permanently coated or light-coloured firefighters' boots are expensive and impractical

Bailey, M. (1979). Insulated boots - field and laboratory evaluation. *Fire Technology*, 15, 283 - 290.

Keywords: 18,43,17,36,23,47,11,29,24,
FLAMMABILITY, THERMAL PROTECTION, FIREFIGHTERS' PROTECTIVE CLOTHING, PROTECTIVE FOOTWEAR, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), WEARING COMFORT, DURABILITY OF F R FIBERS, MILITARY PROTECTIVE CLOTHING, INSULATIVE PROPERTIES,

(Copy on file)

Abstract:

Knee-length insulated firefighter boots and aluminum spats tested to determine the relative effectiveness of insulated boots vs. standard boots and to determine the usefulness of aluminized reflective spats for protection against radiant heat.

Navy and airforce crash firefighters wore the insulated boots and spats for 4 months during severe training exercises and routine details. They then completed a detailed questionnaire comparing the test boots to standard boots.

Test sites represented a variety of climatic conditions - sub-tropical to arctic.

Questionnaire: Overall Acceptance - preferred insulated boots; Heat Protection - good to excellent for insulated, fair to adequate for standard; Fit, Traction, Mobility, Comfort - insulated superior; Durability - would last as long as standard boots.

May need layers of socks to protect from arctic cold.

Spats: Rayon spats fastened by leather straps, Nomex spats had nylon-velcro fasteners.

Results: leather straps too short (not suitable); mud hindered velcro (not suitable); felt spats unnecessary as expected to be protected by insulation; spats easily soiled and required care to maintain reflective surface; some realized necessity if unexpected entrapment to protect against high doses of infrared radiation from fire.

Conclusion: insulated boots more protective than standard boot and preferred by firefighters; reflective spats effective but felt unnecessary for day-to-day use when insulated boots are worn; spats necessary if firefighters immobilized and exposed to high heat; spats could prolong wear and protect outer surface of boots.

Bailey, M. & others (1984). Evaluation of flammability of footwear upper materials: patent and regular shoe upper leather vs. porvair and clarino poromerics. *Journal of Coated Fabrics*, 13, 239 - 249.

Keywords: 43,18,23,26,36,
THERMAL PROTECTION, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), LEATHER,
PROTECTIVE FOOTWEAR,

(NO Copy on file)

Abstract:
General Findings, flammability and heat transfer characteristics of poromeric versus leather shoe upper materials are discussed.

Poromerics - permeable synthetic materials with a glossy shine - leather - cattlehide

Flammability Measurements - vertical flame test - poromerics totally consumed in 94 sec. or less and melted while burning - leather showed excellent flame-resistance, short after-flame and after-glow times and char length O.I.

Heat transfer measurements -fire simulator test
- Condition 1 (1.00 gcal/cm2/sec. - 15 sec.) - poromerics softened, melted and sagged even when supported with poromeric-aluminum doubler-polyester cotton lining although heat was retarded better; leather didn't sag but the leather finishes melted, supported leathers had heat transfer values as low as supported poromerics and melted less than unsupported leather.
- Condition 2 (0.50 gcal/cm2/sec. - 30 sec.) - unsupported poromerics softened, melted less than in 1, but one shrank. Supported PR leathers had smaller heat transfer values than in 1. Supported had condensed moisture on foil interlining.
- Condition 3 (0.50 gcal/cm2/sec. - 90 sec.) - unsupported poromerics, effect on finish same as 2 - CI softened and melted and shrank - unsupported leathers were minimally affected - therefore high heat pulse for short time does more damage than low heat flux for long time (more time for materials to lose heat to the environment).

Hot foot tests - all urethane finishes slightly affected

Solvent Burn Tests (toluene) - polyurethane finishes melted

Results: poromerics potentially hazardous in high heat; patent leather more comfortable and protective; standard more fire resistant and least susceptible to damage from flames and hot objects; leathers had significantly higher heat transfer than poromerics when unlined; lined - no disadvantage.

Baitinger, W.F. & Beard, M.L. (1976). Heat flux testing of apparel fabrics. *Proceedings of the 1976 Symposium on Textile Flammability*, 89 - 115.

Keywords: 23,18,40,43,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, TESTING AND TEST METHODS, THERMAL PROTECTION,

(Copy on file)

Abstract:
Govmark MAFT apparatus was employed.

Baitinger, W.F. (1979). Product engineering of safety apparel fabrics: insulation characteristics of fire-Retardant cottons. *Textile Research Journal*, 49, 221 - 225.

Keywords: 18,43,10,23,12,14,24,
FLAMMABILITY, THERMAL PROTECTION, COTTON,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), F R FINISHES,.
FABRIC CONSTRUCTION, INSULATIVE PROPERTIES,

(NO Copy on file)

Abstract:
A set of cotton fabrics were studied to consider the factors to which the heat transmission characteristics were related most significantly.

Each fabric was treated with a FR finish and applied to the fabrics under commercial conditions in a finishing plant. Some fabrics were then treated with a crosslinking resin and some were compressively shrunk.

The fabrics were exposed to different flame and radiation sources.

Protection time was found to relate best to fabric thickness in low, radiant heat.

Nature of the exposure, spatial relationship of the fabric and sensor, fabric properties (optical and physical) are factors important to insulative characteristics

As radiative flux is raised, factors in addition to fabric thickness may be important.

The resin-treated cottons that varies in colour offered slightly more protection then average - either the optical properties or a beneficial effect of resin treatment are contributing favorably to protection.

To engineer product safety appropriately, the actual hazard against which protection is required must be properly identified - may vary significantly from end-use to end-use.

Baitinger, W.F. (19xx). Fire retardance characteristics of safety apparel fabrics. *Cotton Incorporated*, 168.

Keywords: 43,37,23,18,11,31,12,14,16
THERMAL PROTECTION, REGULATIONS AND STANDARDS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY,
DURABILITY OF F R FIBERS, MOLTEN METAL EXPOSURE, F R FINISHES,
FABRIC CONSTRUCTION, FABRIC SYSTEMS,

(Copy on file)

Abstract:

The hazard against which a worker is being protected varies with occupation and therefore the fabric's safety requirements will also differ with occupation.

In determining appropriate fabrics for different end uses, heat transfer characteristics of fabrics of differing constructions, weights and colours were studied. All fabrics were inherently flame resistant either by nature or treatment.

Heat transmission characteristics were measured using either a flame source or a radiant heat source. The temperature used in the 'skin' sensor behind and in contact with the fabric is measured and converted to time-to-pain or time-to-blister.

Results:
Convection - higher protective capacity with increasing fabric thickness; decreasing air permeability of fabric extends protection time.

Radiation - increased protection with increasing fabric weight and decreasing air permeability; the net protective effect depends on both the spectral characteristics of the source and the optical properties of the fabric.

Molten Metal Contact - actual fabric damage as well as heat transmitted reveal the protective properties; samples are tested with an underlayer of cotton knit underneath to simulate undergarments; Steel tests - all fabrics offer high protection with no breakthrough or melting with the possible exception of the twill weave (more open); Aluminum - phosphorus containing finishes caused the aluminum to stick to the fabric thus, heat was retained at the fabric surface and added heat transferred through the fabric upon solidification. Although untreated fabrics perform better than those with FR finishes, they run a high risk of ignition from the molten aluminum if any is retained in any fold.

Barker, R.L. & Yener M. (1981). Evaluating the resistance of some protective fabrics to molten iron. *Textile Research Journal*, 51, 533 - 541.

Keywords: 43,28,23,11,31,14,21,18,40,
THERMAL PROTECTION, METALLIZED FABRICS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
DURABILITY OF F R FIBERS, MOLTEN METAL EXPOSURE, FABRIC CONSTRUCTION,
GARMENT DESIGN, FLAMMABILITY, TESTING AND TEST METHODS,

(NO Copy on file)

Abstract:
Twenty-two different protective fabrics including aluminized and nonaluminized fabrics were studied with regard to their ability to withstand heat transfer and thermal disintegration on impact with molten metal.

A known weight of molten iron was poured onto the fabric behind which was a layer of 3 oz. cotton knit. The heat flow was measured by a copper calorimeter and the temperature use monitored for a 4 sec. interval. The temperature use with time, coupled with the calorimeter constants were used to calculate heat flux through the fabric. The amount and character of the damage was rated subjectively as: 1) charring, 2) shrinkage, 3) perforation or burn-through, 4) adherance of the metal to the fabric. Fabrics were measured for weight, thickness, air permeability and flammability.

Aluminized fabrics performed well in deflecting heat and were not greatly affected by type of base fiber or construction. Not aluminized, FR wool, treated asbestos and heavyweight silica best resistance to heat. Aluminized judged least damaged after impact of nonaluminized only asbestos had no burn-through. The others were to some extent charred and perforated. Searing and burning were particularily evident in aramid, novoloid, modacrylic and non-alum. cotton. Only one alum. fabric suffered charring and perforation as other fabrics. Only aramid and modacrylic shrank.

Found direct relationship between fabric thickness and weight and fabric capacity to insulate against molten metal. Fabrics with high air permeability were less resistant to the flow of heat from the molten iron. No obvious disadvantage could be seen for differing base fabrics of alum. fabrics.

Alum. fabrics seen as dissipaters of heat and as enhancing faric integrity.

Asbestos treated with a special finish to impound fibers did well.

Heavier fabrics of inorganic materials (ceramic, silica) provided some resistance to heat.

Lightweight and fabrics formed from polymers that degrade at elevated temp. badly damaged.

Fabric weight and thickness as well as a design which limits air permeability and flammability important - if degraded by exposure to vertical flame the fabric will disintegrate in the more intense heat generated by molten steel.

Barker, R.L., Yener, M.D. (1981). Protective clothing: evaluating the performance of asbestos substitutes against molten steel. *Proceedings of the International Conference on Fire Safety*, Products Safety Corporation, SRI International, Menlo Park, CA 94025

Keywords:

(Copy NEVER VIEWED)

Abstract:

Barker, R.H. (1981). The physical and thermal properties of shell fabrics for firefighters turnout coats. *Proceedings on Fire Safety*, 6.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Barker, R.L. & Brewster, E.P. (1982). Evaluating the flammability and thermal shrinkage of some protective fabrics. *Journal of Industrial Fabrics*, 1(1), 7 - 17.

Keywords: 1,4,10,11,12,13,14,15,18,30,35,40,42,43,
ARAMID (NOMEX, KEVLAR), BLENDS, COTTON, DURABILITY OF F R FIBERS, F R FINISHES, F R WOOL (ZIRPRO), FABRIC CONSTRUCTION, FABRIC IGNITION TIME, FLAMMABILITY, MISCELLANEOUS F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS, TESTING AND TEST METHODS, THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION,

(Copy on file)

Abstract:
This research examines the flammability and thermal shrinkage of a number of heat resistant fabrics that might be suitable for use in industrial safety equipment. More than 60 fabrics representing different fiber types, weights, finishes, and constructions are tested. Thermal resistance is evaluated in laboratory tests designed to emphasize the differences that exist in the thermal properties of widely differing nonflammable materials. Flammability is measured in prolonged exposure to a vertical flame and in procedures that use limiting oxygen equipment to characterize the burning behaviour. Experiments that measure fabric shrinkage following oven treatments at temperatures of 300 and 400 C are discussed. The effect of fabric construction on thermal resistance is examined, as are the benefits gained by blending different types of high temperature fibers, the role of aluminum layers and the use of novel yarn structures.

Barker, R.L., & Brewster, E.P. (1983). A summary of research on heat resistant fabrics for protective clothing.. *American Industry Hygiene Association Journal*, 44(2), 123-130.

Keywords: 42,43,
THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION,

(NO Copy on file)

Abstract:

Barker, R.L., & Lee, Y.M.. (1985). Thermal insulation properties of fabrics in high-intensity heat exposures.. *Tappi Journal*, 66(12), 62-67.

Keywords: 24,43,23
INSULATIVE PROPERTIES, THERMAL PROTECTION,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(NO Copy on file)

Abstract:

Barnhart, W.L., Toney, C.R., & Nicodemus, L.A. (1974). Catalog of available protective clothing supplement to final report: protective clothing - assessment of need. National Institute for Occupational Safety and Health.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Barnhart, L. (1974). Protective clothing - assessment of need. *Personal Protection, A Symposium*, U.S. Dept. of Health, Education and Welfare and the National Institute for Safety and Health Administration, NIOSH 75-143, W

Keywords:

(Copy NEVER VIEWED)

Abstract:

Barnhart, W.L., Toney, C.R., & Nicodemus, L.A. (1974). Protective clothing: assessment of need, vol. 1. Washington: U.S. Department of Health, Education and Welfare, National Institute for Occupational Safety and Health.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Barnhart, W.L., Toney, C.R., & Nicodemus, L.A. (1974). Protective clothing - assessment of need vol. II. Washington: U.S. Department of Health, Education and Welfare, National Institute for Occupational Safety and Health.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Barnhart, L. (1975). Protective clothing - assessment of need. *Personal Protection, A Symposium.* Washington: U.S. Dept. of Health, Education and Welfare and the National Institute for Safety and Health Administration.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Beck, K. (1975). Part 2: clothing and equipment. *Fire Engineers Journal*, 35(100), 36 - 38.

Keywords: 43,47,41,1,8,21,
THERMAL PROTECTION, WEARING COMFORT, THERMAL / HEAT STRESS, ARAMID (NOMEX, KEVLAR), CLOTHING SYSTEMS, GARMENT DESIGN,

(NO Copy on file)

Abstract:

Protective clothing needs to protect against a number of differing environments and the entire body should be protected.

Comfort important - metabolic heat must be allowed to evaporate, the clothing should allow movement to induce cool air while the garment must look smart to encourage the worker to give his best.

Nomex - high resistance to heat, extremely strong, lightweight, good chemical resistance, non-allergenic and materials made from it are able to breathe and so are comfortable to wear.

Multi-layer garments give better protection against flames and adverse weather.

Collar - protection against cold and water; Velcro - seal down front; loose cut allows for freedom of movement and provides for ventilation to the body.

Possible 2 pairs of gloves - one plastic to protect against water, chemicals and for general wear; one of lined Nomex to protect against burns, cold and 'flashover' situations.

Helmet similar to race car driver would provide increased stability and better protection to ears and lower part of the skull.

Behnke, W.P. & Seaman, R.E. (1966). Development of clothing for protection from convective heat. *Fire Technology*, 2(3), 219 - 225.

Keywords: 43,18,23,14,6,40,
THERMAL PROTECTION, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FABRIC CONSTRUCTION,
BURN INJURY, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

When designing protective clothing for hazardous thermal environments, the clothing must not contribute to the injury by burning, melting or disintegrating. The clothing must act as a thermal barrier that will protect the wearer for a given length of time.

Human tissue damaged when temperature reaches a critical level. The temperature rise is due to heat being delivered to the tissue at a faster rate than it can be dissipated by the body. Exposure time significant in amount of temperature rise.

The method of heat transfer, the magnitude of the heat flux, and the length of time protection must be combined with a testing method which is similar to field conditions. If data is in the form which can be interpreted in terms of tissue damage, then, using the information it should be possible to design a protective clothing system for the exposure under study.

Various fabrics were tested. The addition of a second layer of fabric increased the mass of material that must be consumed before the wearer is injured and trapped large quantities of air which improved the insulating qualities of the garments.

Greater fabric thickness provided greater protection.

Behnke, W.P. & Seaman, R.E. (1969). Develop novel test equipment in fabric heat transfer study. *Modern Textiles Magazine*, 50, 19 - 24.

Keywords: 8,11,14,15,16,18,21,23,24,28,40,42,43,
CLOTHING SYSTEMS, DURABILITY OF F R FIBERS, FABRIC CONSTRUCTION,
FABRIC IGNITION TIME, FABRIC SYSTEMS, FLAMMABILITY, GARMENT DESIGN,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES,
METALLIZED FABRICS, TESTING AND TEST METHODS,
THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION,

(Copy on file)

Abstract:
An accurate evaluation of protective clothing requires exposures similar to those encountered in use. the type of exposure, convective, radiant or conductive and the amount of heat transmitted must also be known.

Thermal hazards can be classified:
1) The fabric is a hazard therefore nonflammability is important. As well, the garment should be comfortable, pleasing aesthetically and have high durability.
2) much higher exposure levels require not only nonflammability but insulation from the hot environment (external hazard):
a) Convective exposure (transfer of heat by hot gases): the primary variable is fabric thickness - the charring and puckering of Nomex on exposure to flames causes an increase in effective thickness, giving a higher level of protection.
b) Conductive exposure (contact with hot objects): Primary variable is fabric thickness. Primary insulating material is air trapped within the fabric. High temp. resistant, low density Nomex fabrics performed best.
c) Radiant exposure: Heat transmission characteristics are determined by the aluminum coating not the thickness or weight of the base material. The base fabric must be high temp. resistant.

Behnke, W.P. & Seaman, R.E. (1969). Laboratory tests which predict end-use performance under high temperature conditions. *Applied Polymer Symposia*(9), 49 - 62.

Keywords: 8,11,14,15,16,18,23,40,43,
CLOTHING SYSTEMS, DURABILITY OF F R FIBERS, FABRIC CONSTRUCTION, FABRIC IGNITION TIME, FABRIC SYSTEMS, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), TESTING AND TEST METHODS, THERMAL PROTECTION,

(Copy on file)

Abstract:
Laboratory tests are essential tools for predicting performance in high temperature uses since they reduce the time and effort required to evaluate new products. At the present time, high temperature fibers find their major utility in industrial uses. These can be broadly divided into two classifications: a) uses involving long-term exposure to elevated temperatures - either continuous or cyclic; and b) areas where fibres are exposed to only once during their useful life to a high energy source sufficient to cause fiber damage or destruction. Major end uses are classified according to the above criteria and performance parameters associated with them are described. These parameters are, in turn, related to existing and new laboratory tests used to judge acceptability. Pitfalls inherent in the use of such tests are described and criteria for product acceptance or rejection are outlined.

Behnke, W.P. (1977). Evaluation of thermal protection provided by clothing. Source unknown -- paper November 16 - 18, 1977.

Keywords: 35,23,17,18,19,43,6,40,
PHYSICAL PROPERTIES OF F R FIBERS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, FLASH FIRES,
THERMAL PROTECTION, BURN INJURY, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Firemen need protection from the weather and flash fires. Factory workers need protection from flash fires.

Clothing must be flame-resistant and protective, durable, comfortable, neat, attractive and economical.

Protective clothing used to prevent burns when a worker is exposed to a thermal hazard. Protective performance is a measure of a fabric's ability to prevent heat transfer great enough to cause burn injury. To minimize heat transfer, fabrics must provide a barrier of high integrity to isolate wearer from the exposure and insulate for extended exposure when outer fabric becomes too hot.

Fabrics should not ignite, break open when exposed to heat or have excessive weight loss or release materials which may increase haet transfer. Fabrics should have low shrinkage and be strong enough to remain in place even if the wearer is running.

Evaluation techniques must have realistic exposure, proper arrangement of samples and appropriate heat sensor.

Heat transfer depends on effectiveness of clothing and thermal characteristics of the exposure. Fabric response to exposure depends on the level and type of energy of the exposure; therefore, the correct level and combination of convective, conductive and radiant heat is necessary when testing. Also, the relative positions of exposure, test sample and heat sensor important.

Failure of protective clothing should not occur before the length of time necessary to escape the exposure.

Behnke, W.P. (1977). Thermal protective performance test for clothing. *Fire Technology*, 13(1), 6 - 12.

Keywords: 43,14,16,18,21,23,24,28,40,42,
THERMAL PROTECTION, FABRIC CONSTRUCTION, FABRIC SYSTEMS, FLAMMABILITY, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES, METALLIZED FABRICS, TESTING AND TEST METHODS, THERMAL PROPERTIES OF F R FIBRES,

(Copy on file)

Abstract:

Improved evaluation methods required with the development and commercialization of clothing materials which are not only flame resistant to thermal exposures but act as tough thermal barriers.

Flammability tests, designed as quality control for flame retardant treatments do not adequately rate the performance of the new materials.

The test must measure the heat transmitted to the wearer which causes injury.

The heat transferred depends on the exposure and the insulative or protective performance of the garment material.

In testing, a proper balance of convective and radiant energy must be met for flame exposures and the exposure must be at a similar level as in the end-use exposure.

The heat transmitted through the garment must be judged for the degree of injury it will cause. Second degree burn is used as a criterion as it is easily identified.

Clothing material rated by the amount of the heat of exposure that results in heat transfer just sufficient to cause a second degree burn.

The total heat of exposure, determined from the time and ther level of exposure is a direct measure of the protective capabilities of the test material. TPP rating.

5 fabrics are evaluated.

An improvement in protective rating occurs with increasing number of layers, weights and thicknesses.

Also an improvement when an outer aluminized layer is added to reflect the radiant energy component of the exposure.

Behnke, W.P. (1978). Aramid fibres for protective clothing. *Proceedings of the 1978 Symposium on Textile Flammability.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Behnke, W.P. (1984). Predicting flash fire protection of clothing from laboratory tests using second-Degree burn to rate performance. *Fire and Materials*, 8(2), 57 - 63.

Keywords: 6,8,15,18,19,21,23,24,27,40,42,43,46,
BURN INJURY, CLOTHING SYSTEMS, FABRIC IGNITION TIME, FLAMMABILITY, FLASH FIRES, GARMENT DESIGN,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES, MANNEQUINS, TESTING AND TEST METHODS, THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION, WEAR STUDY METHODS,

(Copy on file)

Abstract:
Laboratory tests have been developed that evaluate realistically the protective performance of clothing material and garments. Test conditions are chosen to stress the high temperature resistance of materials in the same manner as in an industrial flash fire exposure. A second-degree burn in human tissue is used as the criteria to rate performance of materials. Test results have been correlated between the small-scale lab swatch test and a full-scale instrumented manikin garment test and these results related to industrial experience. The TPP lab test has been found useful in evaluating the performance of candidate materials as replacement for existing materials with known acceptable protective performance. It can be used to specify the level of protection needed in a garment when the intensity of the exposure hazard is known. Also the test is especially useful for developing new materials and selecting candidates for additional field testing.

Bell, C.R. & Provins, K.A. (1963). Relation between physiological responses to environmental heat and time judgement. *Journal of Experimental Psychology*, 66(6), 572 - 579.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Bell, C.R., Hellon, R.F., Hirons, R.W., Nicol, P.B. & Provins, K.A. (1965). Safe exposure of men to severe heat. *Journal of Applied Physiology*, 20, 288 - 292.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Bell, C.R. & Walters, J.D. (1969). Reactions of men working in hot and humid conditions. *Journal of Applied Physiology*, 27, 684 - 686.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Benisek, L. (1972). New aspects of flame protection using wool - versatile, simple, inexpensive. *International Dyer and Textile Printer*, 147, 414 - 419.

Keywords: 13,18,43
F R WOOL (ZIRPRO), FLAMMABILITY, THERMAL PROTECTION,

(NO Copy on file)

Abstract:

Benisek, L.. (1974). Improvement of the natural flame resistance of wool. Part II: Multi-purpose finishes,. *Journal of the Textile Institute*, 65(3), 140-145.

Keywords: 12,13,15,18,
F R FINISHES, F R WOOL (ZIRPRO), FABRIC IGNITION TIME, FLAMMABILITY,

(NO Copy on file)

Abstract:

Benisek, L. (1976). Improvement of the natural flame-Resistance of wool - 4. wool-Rich blends with polyester fiber and nylon. *Journal of the Textile Institute*, 67(7), 261 - 265.

Keywords: 4,13,12,14,18,
BLENDS, F R WOOL (ZIRPRO), F R FINISHES, FABRIC CONSTRUCTION, FLAMMABILITY,

(NO Copy on file)

Abstract:
Results of an experimental investigation are presented which show that wool-polyester fiber and particularly wool-nylon blends show a significant negative duration of limiting-oxygen index (LOI) from the average, calculated values. This is probably due to the higher heat of combustion and lower LOI of polyester fiber and particularly of nylon when compared to wool. Consequently, wool-rich blends with nylon are more difficult to flame-resist-treat with metal complexes than wool-polyester blends. In the former blend, at least 75% flame-resistant wool and, in the latter blend 60 - 90% flame-resistant wool has to be present to enable wool-rich blends to be obtained, the exact amount depending on the fabric construction. The hexafluorozirconate treatment is effective on blends containing at least 85% wool, whereas zirconium-tungsten complexes have to be applied for blends with lower wool contents.

Benisek, L. & Phillips, W.A. (1979). Evaluation of flame-retardant clothing assemblies for protection against convective heat (flames). *Clothing Research Journal*, 7(1), 2 - 20.

Keywords: 43,6,13,8,16,14,24,1,32,30,23,18
THERMAL PROTECTION, BURN INJURY, F R WOOL (ZIRPRO), CLOTHING SYSTEMS, FABRIC SYSTEMS, FABRIC CONSTRUCTION, INSULATIVE PROPERTIES, ARAMID (NOMEX, KEVLAR), NOVOLOID (KYNOL), MISCELLANEOUS F R FIBERS, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY,

(Copy on file)

Abstract:

Two-layer assemblies of outerwear woven FR fabrics offered twice the protection of one layer and the fiber composition of the outerwear fabric was of paramount importance. In the case of the innerwear fabric, fabric construction (high thickness, low density) was more important then fiber composiion.

A woven Zirpro wool fabric of high density over a bulky knitted Zirpro wool underwear fabric offered significantly better protection against flames than a single layer of a woven or knitted FR fabric or a double layer of a woven FR fabric of the same total weight. This is associated with the insulating air layer entrapped in the knitted fabric. Zirpro wool fabric assemblies showed the longest time to reach pain (first degree burns) and blister (second degree burns) thresholds, as well as the longest pain alarm time - the time available to the wearer to withdraw from the flame source before serious injuries occur. Zirpro wool fabric assemblies had one of the lowest residual heat transfers after a limited flame exposure to pain threshold, while some of the fibres (aramid and novoloid) transferred significant residual heat, possibly causing second degree burns.

Benisek, L., Edmondson, G.K & Phillips, W.A. (1979). Protective clothing - evaluation of wool and other fabrics. *Textile Research Journal.*

Keywords: 23,41,18,14,24,28,31,13,42,43,47,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL / HEAT STRESS, FLAMMABILITY, FABRIC CONSTRUCTION, INSULATIVE PROPERTIES, METALLIZED FABRICS, MOLTEN METAL EXPOSURE, F R WOOL (ZIRPRO), THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION, WEARING COMFORT,

(Copy on file)

Abstract:
Protective clothing against heat and flames should be evaluated not only for flame-resistance but also for protection against various heat exposures from convection, radiation and conduction sources, depending on the end-use, to ensure a realistic assessment of the potential protection offered and required. Evaluations of various flame-resist-treated fabrics to different heat exposures showed that the fiber and the flame-retardant finish should preferably form a well-developed char on exposure to heat, without softening and melting. The flame retardant should act in the solid phase and the fiber should be of low thermal conductivity. Properties of fabric construction such as density and thickness are also important. For protection against convective heat, a woven fabric of high density and integrity after exposure to flames, over a bulky knitted underwear fabric, appears to be the best approach. Aluminized fabrics are essential for protection against radiant heat, and the aluminization technique affects heat transfer significantly. A low-density base fabric reduces heat transfer in this case. For protection against conduction, such as from molten aluminum splashes, the fabric should have a smooth surface, high density and thickness, besides the other previously mentioned basic requirements. Of the fabrics evaluated, Zirpro wool of adequate construction for the end-use required, offered one of the best protections in the various heat-exposure tests.

Benisek, L., Edmondson, G.K. & Phillips, W.A. (1979). Protective clothing: evaluation of zirpro wool and other fabrics. *Fire and Materials*, 3(3), 156 - 166.

Keywords: 12,13,18,23,31,42,43
F R FINISHES, F R WOOL (ZIRPRO), FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), MOLTEN METAL EXPOSURE,
THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION,

(Copy on file)

Abstract:
This paper summarizes the results of previous evaluations of the protection offered by various FR fabrics and assemblies against convective (flames), conductive (molten aluminum splashes) and radiant heat.

Benisek, L. & Edmondson, G.K. (1981). Protective clothing fabrics: part 1. Against molten metal hazards. *Textile Research Journal*, 51, 182 - 190.

Keywords: 31,23,1,18,42,43,38,13,12,10,1,2,
MOLTEN METAL EXPOSURE, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), ARAMID (NOMEX, KEVLAR), FLAMMABILITY, THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION, SKIN SIMULANT, F R WOOL (ZIRPRO), F R FINISHES, COTTON, ARAMID (NOMEX, KEVLAR), ASBESTOS,

(NO Copy on file)

Abstract:
Purpose of project to evaluate heat transfer from molten metal on various flame-retardant fabrics. The effect of metal temp. on heat transfer also studied.

The molten metal was poured onto the fabric which has a simulated PVC skin behind it. Damage to the'skin' and adherence of the metal to the fabric examined. The test was carried out at varying weights to determine the minimum of metal necessary to just damage the 'skin'.

Molten Cast Iron: Increased fabric weight and higher density at a given fabric weight increased protection. Zirpro wool and FR cotton found best.

Molten Steel: Only slight difference between the 3 steels on Zirpro wool. Other fabrics reacted similarly to iron except EN8 did not adhere to aramid.

Molten Copper: results similar to iron with regard to the effect of fabric weight, density, and fiber composition. Most fabrics required less copper to damage 'skin' - no copper adhered to the aramid.

Molten Aluminum: adhered to aramid, glass, asbestos, FR cotton and caused damage to 'skin' at low weights. FR wool and untreated cotton not stuck to.Organophosphorous-based fire retardants had adverse effects on cotton. Untreated cotton required less metal than FR wool and ignited during test.

Molten Zinc: Untreated wool and Zirpro wool and untreated cotton required more metal than other fabrics. Metal adhered to all except untreated cotton least affected.

Molten Lead: Adhered to all fabrics. FR treatments lowered protection of cotton. Wool required most metal-treated and untreated. Glass, asbestos lowest protection.

Molten Tin: Adhered to all but not as much as zinc and lead. FR and untreated wool and untreated cotton best protection. Glass, asbestos least effective.

For optimum protection, fibers should not be thermoplastic, have a low thermal conductivity, should form char. Fabric surface should be smooth to prevent entrapment of the metal.

Zirpro wool had superior protection, untreated cotton slightly lower, FR treatments adversely affected protection against aluminum, zinc, lead, tin. Aramid, asbestos, glass poor as softening at around 318C for aramid and high

thermal conductivity of other two.

Benisek, L. & Phillips, W.A. (1981). Protective clothing fabrics part II. against convective heat (open flame) hazards. *Textile Research Journal*, 51, 191 - 196.

Keywords: 6,13,12,8,16,14,24,1,32,30,23,18,43
BURN INJURY, F R WOOL (ZIRPRO), F R FINISHES, CLOTHING SYSTEMS, FABRIC SYSTEMS, FABRIC CONSTRUCTION, INSULATIVE PROPERTIES, ARAMID (NOMEX, KEVLAR), NOVOLOID (KYNOL), MISCELLANEOUS F R FIBERS, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, THERMAL PROTECTION,

(Copy on file)

Abstract:
Protective clothing against heat and flame must be tested not only for flame retardance but for protection from convection (flames), conduction (molten metal splashes) and radiation sources.

The fiber and FR finish should form well-developed char on exposure to heat without softening or melting. The FR should work in the solid phase and the fiber be of low thermal conductivity.

Results:

Effect of Air Separation: Generally, the larger the more protection offered against convective heat.

Effect of Fabric (Assembly) Weight: Increased weight leads to longer time to second degree burns although fabric density is also a factor. The use of two layers of innerwear produced longer pain and second degree burn threshold times for the three outerwear fabrics evaluated.

Effect of Imposed Heat Flux: The increased imposed heat flux decreased the time for pain, second degree burns and pain-alarm time.

Benisek, L. & Edmondson, G.K. (1983). Flame-Retardant, petrol, oil, water and acid repellent wool. *Textile Research Journal*, 53(6), 329 - 334.

Keywords: 1,13,18,7,12,
ARAMID (NOMEX, KEVLAR), F R WOOL (ZIRPRO), FLAMMABILITY, CHEMICAL RESISTANCE, F R FINISHES,

(NO Copy on file)

Abstract:
Fabric 1 - chrome-dyed, navy blue-black, 100% wool barathea fabric, 368 g/m**2, 0.82 mm thick, 0.45 g/cm**3 density

Fabric 2 - 100% wool gabardine, dyed with reactive dyes to orange shade, 280 g/m**2, 0.90 mm thick, 0.31 g/m**3 density

Commercial aramid - Nomex III

All fabrics scoured and rinsed before Zirpro and fluorocarbon treatment - applied simultaneously by exhaustion technique to achieve flame-resistancy, petrol, oil and water and acid repellency.

Flame Resistancy - FAR 25.853b - vertical flame, 12 sec. ignition

Oil Repellency - hydrocarbon resistance test, AATCC 118, 1975

Water Repellency - spray rating test BS 3702:1964 - % weight increase also measured. Simulated Petrol Bomb test, Gutter test and Drycleaning fastness also examined.

For effective oil, water and petrol repellent treatment, the chemical composition and concentration of the fluorocarbon and chemical structure and physical parameters of the fabric substrate are important.

Aramid fibers more oleophilic and hydrophobic than wool as the same concentration of Nura F resulted in inferior oil, water and petrol repellency.

Multipurpose treatment is fast to at least 25 charged drycleanings with anonionic drycleaning detergent.

Benisek, L. (1983). Virgin wool products with flame-retardant finish. *Melliand Textilberichte - International Textile Reports*, 64: 559 - 565.

Keywords:

(Copy NEVER VIEWED)

Abstract:
The overall flammability performance of Zirpro wool products is summarized. Such parameters as flame-retardancy, convective heat transfer, conductive heat transfer, protection against combustibles and hazardous chemicals, smoke generation and toxicity of combustion products are examined as they relate to heat and fire-protective apparel and textile furnishings.

Benisek, L. (1985). Zirpro wool textiles. *Fire and Materials*, 8(4), 183 - 195.

Keywords:

(Copy NEVER VIEWED)

Abstract:
The flammability of wool protective clothing with Zirpro flame retardant treatment was evaluated with respect to national and international flammability standards. Considerations for the proper assessments of textile flammability hazards are discussed.

Benisek,L.. (1974). Improvement of the natural flame resistance of wool. Part I: metal-complex applications.. *Journal of the Textile Institute*, 65(2); 102-108.

Keywords: 13,30,18,15,31
F R WOOL (ZIRPRO), MISCELLANEOUS F R FIBERS, FLAMMABILITY, FABRIC IGNITION TIME, MOLTEN METAL EXPOSURE,

(NO Copy on file)

Abstract:

Bennett, E.M. et al. (1963). Human Factors in Technology. New York: McGraw Hill.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Bennett, J.A. (1983). A new angle on fire fighter safety. *Fire Service Today*, 30 - 31.

Keywords: 17,18,43,
FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, THERMAL PROTECTION,

(Copy on file)

Abstract:
Three specific elements of firefighter safety: protective clothing and equipment, training and physical fitness. The article discusses each element individually in respect o new advances and change in each.

Berger, M.R. (1976). Safety clothing: a matter of personal protection. *National Safety News*, 114(3), 63 - 67.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Bingham, M.A., Hill, B.J.. (1975). A study of the thermal behavior of flame-resistant fibres and fabrics.. *Journal of Thermal Analysis*, 7(2), 347-358.

Keywords: 12,18,14,23,35
F R FINISHES, FLAMMABILITY, FABRIC CONSTRUCTION,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
PHYSICAL PROPERTIES OF F R FIBERS,

(NO Copy on file)

Abstract:

Bingham, M.A. & Hill, B.J. (1976). Comparison of thermal characteristics of materials examined by thermogravimetry and flammability tests. *Journal of Thermal Analysis*, 9, 71 - 78.

Keywords: 18,40,27,25,38,6,33,32,10,30,4,1,
FLAMMABILITY, TESTING AND TEST METHODS, MANNEQUINS, JP-4 FUEL FIRES,
SKIN SIMULANT, BURN INJURY, PBI, NOVOLOID (KYNOL), COTTON,
MISCELLANEOUS F R FIBERS, BLENDS, ARAMID (NOMEX, KEVLAR),

(Copy on file)

Abstract:
Different flame-resistant fabrics afford different degrees of protection to a wearer under conditions of fire but existing laboratory test methods do not differentiate between them as protective clothing. The work described here was undertaken with a view of devising a laboratory method for fabrics which would correlate with the pit test in which a dressed manikin is pulled through a pit of blazing JP-4 jet fuel and the 'skin' temperature is measured at various points and the time for 20% damage of the skin is calculated. Eight fabrics (PBI, Nomex, Kermel ,Kynol, Durette, Leavil, Proban-treated cotton, and a 50/50 blend of Kynol/Nomex) were examined. It is shown that thermogravimetric methods may be used to predict the behavior of fabrics in the pit test and hence in practice.

Blockley, W.V. (1968). Quantitative assessment of the thermal burden imposed by clothing. *Environmental Research*, 2, 11 - 21.

Keywords: 40,8,41,47,9,
TESTING AND TEST METHODS, CLOTHING SYSTEMS, THERMAL / HEAT STRESS, WEARING COMFORT, COMFORT ASSESSMENT,

(NO Copy on file)

Abstract:
A rationale has been developed and tested experimentally, permitting the intercomparison of clothing assemblies as to the thermal burden they impose. The validity of the technique rests on the extensive research on thermal responses of nude men pioneered by Nielson, Lin, Wyndham and others and avoids most problems of inter- and intra-individual differences by utilizing as the criterion parameter the shift in the boundary between environment-independent and environment-driven climate zones (as determined by the equilibrium rectal temperature).

When the boundary shift is expressed in terms of P4SR scale of environment stress, compute for men wearing shorts, the thermal burden imposed by a particular clothing assembly can be conveniently equated to urdens associated with increases in work or in ambient heat load. Further research will be required to establish relationships between boundary shift and such characteristics of clothing as thermal resistance, vapour diffusion resistance, wicking capability, air permeability, fit, etc.

Branson, D.H. (0000). Sweating, comfort, and manual dexterity performance as influenced by chemical-protective glove liners.. Department of Clothing, Textiles, and Merchandising, Oklahoma State University.

Keywords:

(Copy on file)

Abstract:
This paper describes a study done on comfort and dexterity of rubber gloves ì used for protection from chemicals. Skin temperature and sweat rate were ì measured as well as dexterity, comfort and moisture take-up of glove liners. ì It was found that regardless of the liner worn, subjects' skin temperature and ì sweat rate increased over time. Sweat rate was lowest with standard army ì liners and highest for cotton/acrylic liners.

Branson, D.H. (1982). Assessment of thermal response to subjects wearing functionally designed protective clothing. *Dissertation Abstracts International*, 43, 1454B.

Keywords: 21,47,24,8,9,
GARMENT DESIGN, WEARING COMFORT, INSULATIVE PROPERTIES, CLOTHING SYSTEMS, COMFORT ASSESSMENT,

(Copy on file)

Abstract:

Branson, D.H., Dejonge, J.O. & Munson, D. (1986). Thermal response associated with prototype pesticide protective clothing. *Textile Research Journal*, 56(1), 27 - 34.

Keywords: 34,41,47,46,8,7,40,
PESTICIDE PROTECTIVE CLOTHING, THERMAL / HEAT STRESS, WEARING COMFORT, WEAR STUDY METHODS, CLOTHING SYSTEMS, CHEMICAL RESISTANCE, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
In an effort to develop protective clothing that offered improved heat dissipation characteristics to pesticide applicators, the thermal responses were collected from 54 male subjects wearing two prototypes and a typical clothing ensemble. The performance of three designs and three fabrics with known chemical protective characteristics was determined in a controlled laboratory, simulating a hot environment. Analysis of physiological and perceptual data revealed that one protective fabric offered a similar thermal comfort level as chambray, a fabric growers often wear for pesticide application, which is an ineffective barrier to pesticide penetration.

Braun, E., Cobb, D., Cobble, V.B., Krasny, J.F. & Peacock, R.D. (1980).
Measurement of the protective value of apparel fabrics in a fire environment.
Journal of Consumer Product Flammability, 7.

Keywords: 43,24,14,23,16,15,11,40,6,18
THERMAL PROTECTION, INSULATIVE PROPERTIES, FABRIC CONSTRUCTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FABRIC SYSTEMS, FABRIC IGNITION TIME, DURABILITY OF F R FIBERS, TESTING AND TEST METHODS, BURN INJURY, FLAMMABILITY,

(Copy on file)

Abstract:
A method for measuring the protection provided by apparel fabrics in a fire environment is described. A fabric is subjected to a heat load, and the transmitted heat flux is measured. The apparatus can be adjusted to simulate a variety of fire situations: the total incident heat flux can be varied, as well as the ratio of the radiative and convective components; the heat sensor can be in contact with the fabric, or at a distance, simulating looseness of fit of various garments; resistance to ignition can be determined by exposing the heated specimen to a pilot flame; and the heat received by the fabric at which charring or melting occurs can by determined. Typical results on a variety of ignition resistant fabrics are shown and related to fabric construction parameters. The results are expressed in terms of time of exposure until an incipient second-degree burn is likely to occur. This time to injury is estimated based on work of previous investigators [7,11]. Optimum use of the method would involve studying the types of heat exposure to which firefighters and workers in various industries are likely to be subjected and reproducing these conditions in the laboratory.

Breckenridge, J.R. (1977). Effects of body motion on convective and evaporative heat exchanges through various designs of clothing. In N.R.S. Hollies and R.F. Goldman (Eds.) *Clothing Comfort* (pp. 153 - 166). Ann Arbor; MI: Ann Arbor Sciences.

Keywords: 47,21,41
WEARING COMFORT, GARMENT DESIGN, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
SUBTOPICS IN PAPER

1. Factors Determining Heat Removal by Air Movement in Clothing
2. The Physical-Physiological Approach to Measurement of Clothing Heat Transfer
3. Empirical Expressions for Describing Effects of Body Motion
4. Other Approaches in the Assessment of Body Motion Effects

Paper has much information on using equations for information gathered and statistical analysis.

Brewster, E.P., & Barker, R.L. (1982). Bibliography of published information on heat resistant fabrics for protective clothing. *Journal of Consumer Product Flammability*, 9(1), 11 - 19.

Keywords: 23,21,40,18,43,8
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), GARMENT DESIGN, TESTING AND TEST METHODS, FLAMMABILITY, THERMAL PROTECTION, CLOTHING SYSTEMS,

(Copy on file)

Abstract:
This bibliography of 110 references was prepared to assist those working in the field of heat-resistant protective clothing. It will be of special interest to those working in the area of industrial safety apparel, but should also be useful to anyone whose concern is to develop, to test, or to use clothing for protection against heat hazards.

Brewster, E.P. & Barker, R.L. (1983). A summary of research on heat resistant fabrics for protective clothing. *American Industrial Hygiene Association Journal*, 44(2), 123 - 130.

Keywords: 14,18,21,23,43,40
FABRIC CONSTRUCTION, FLAMMABILITY, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Research relating to the performance of heat-resistant safety fabrics is referenced. General requirements for fabrics used for thermal protection are discussed and laboratory methods of testing are summarized. A need is seen for a specific program to evaluate the suitability of the varity of fabrics that are available that might be used in industrial safety apparel.

British Standards Institution. (1970). Specifications for clothing for protection against intense heat for short periods.. BS3791, 2-28.

Keywords: 37,40,21,23,15,18
REGULATIONS AND STANDARDS, TESTING AND TEST METHODS, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FABRIC IGNITION TIME, FLAMMABILITY,

(NO Copy on file)

Abstract:

Brown, Q.R. & Ennis, B.C. (1977). Thermal analysis of nomex and kevlar fibers. *Textile Research Journal*, 47, 62 - 66.

Keywords: 1,11,14,15,18,35,40,42,
ARAMID (NOMEX, KEVLAR), DURABILITY OF F R FIBERS, FABRIC CONSTRUCTION, FABRIC IGNITION TIME, FLAMMABILITY, PHYSICAL PROPERTIES OF F R FIBERS, TESTING AND TEST METHODS, THERMAL PROPERTIES OF F R FIBRES,

(NO Copy on file)

Abstract:
DTA, TG and TMA curves of commercial Kevlar 49 and Nomex fibres have been used to assess their behavior at high temperatures. The fibres lost absorbed water around 100C and a glass transition was reflected in the DTA and TMA curves in the region of 300C. Difficulties in the interpretation of DTA and TMA curves in the glass-transition region and in the assignments of Tg's for these high performance fibres are discussed. Whereas Kevlar 49 showed both a crystalline melting point (560C) and a sharp endothermal thermal decomposition (590C), Nomex showed only the latter (440C) and no evidence of melting from the DTA curves. The endothermal decompostion peaks apparently correspond to "polymer melt temperatures" reported for related materials, and correlate well with the TG and TMA features. During thermal analysis of Kevlar 49, oxidation occurs more readily then thermal decomposition, but the latter predominates for Nomex. Differences between dyed and undyed Nomex were due to differences in yarn constitution.

Bruce, J.P.. (1978). Fire retardant textiles: Where do we stand.. *Modern Textiles*, 59(5), 51.

Keywords: 12,18,42
F R FINISHES, FLAMMABILITY, THERMAL PROPERTIES OF F R FIBRES,

(NO Copy on file)

Abstract:

Burgess, W.A., Sidor, Reinhard, Lynch, Buchanan, J.J., Paul, & Clougherty, E. (1977). Minimum protection factors for respiratory protective devices for firefighters. *American Industrial Hygiene Association Journal*, 38(1), 18 - 23.

Keywords: 5,17,37,
BREATHING APPARATUS, FIREFIGHTERS' PROTECTIVE CLOTHING, REGULATIONS AND STANDARDS,

(NO Copy on file)

Abstract:
Carbon monoxide and oxygen concentrations were measured in 72 structural fires using a personal air sampler carried by working firefighters. In a total sampling time of 1329 minutes the carbon monoxide concentration exceede 500 ppm approximately 29 percent of the time. The maximum carbon monoxide concentration was 27 000 ppm and in 10 percent of the fires, the maximum concentration exceeded 5500 ppm. Only six runs indicated oxygen concentrations less than 18 percent. On the basis of these exposure data, a minimum protection factor of 100 is proposed for breathing apparatus for structural firefighting.

Early experience of the Boston Fire Dept. with self-contained breathing apparatus brought complaints of weight, bulk, limited use time and questionable efficiency.

The protection factor is a measure of the degree of protection afforded by a respirator and is equal to the ratio of the concentration of the conaminant in the ambient atmosphere to that inside the respirator face piece under conditions of use.

Burton, A.C. (1935). Human calorimetry II, The average temperature of the tissues of the body.. *Journal of Nutrition*, 9 , 261-280.

Keywords: 49
BODY TEMPERATURE MEASUREMENT,

(NO Copy on file)

Abstract:

Canadian General Standards board. (1988). Firefighters' protective clothing for protection against heat and flame.. CAN/CGSB 155.1 National Standard of Canada. Ottawa, Canada.

Keywords: 8,17,18,43,40
CLOTHING SYSTEMS, FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, THERMAL PROTECTION, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Cassie, A.B.D. (1949). Characteristics for warmth in underwear fabrics. *Journal of the Textile Institute, Proceedings*, 40, 444 - 453.

Keywords: 47,44,24,14,
WEARING COMFORT, UNDERWEAR, INSULATIVE PROPERTIES, FABRIC CONSTRUCTION,

(NO Copy on file)

Abstract:
Skin reactions and body metabolism are discussed insofar as they determine requirements for clothing, and it appears that thermal insulation combined with a high permeability to water vapour are necessary for the skin to function properly. Heat insulation in fabrics is normally supposed to be due to : entrapped air, but our vague conception of 'entrapped' air shows that it really implies the drag on air movement given by a large total surface of all the fibres in a fabric. The extent of these surfaces is calculated, and some estimates are obtained of the fraction of the total surface which does exert drag on air movements. This accessibility of the fibre surfaces to air is probably the most important factor in determining the 'warmth ' of different fibres. It is shown to be related to the elastic properties of the fibres and wool shows the closest approach to the ideal fibre from this point of view.

Chapman, A.C. (1973). Proban flame retardant finish. *Symposium on Textile Flammability*, 137 - 142.

Keywords:

(Copy NEVER VIEWED)

Abstract:
The Proban flame-retardant finish for cellulosic fabrics together with its ì associated trade-mark and control system are discussed. The Proban (forced ì ammonia cure) treatment of cellulosic fabrics produces a highly durable flame ì and glow resistant finish as the result of the formation of a highly ì cross-linked phosphorous/nitrogen polymer within the cellulose fibres. It has ì several advantages over alternative durable flame-retardant treatments, which ì are listed in some detail. Extensive experimental data is tabulated and ì discussed. The paper is followed by a panel discussion.

Chapman, A.C. & Miller, G. (1980). Fibers, fabrics and finishes for FR workwear in europe. *Journal of Coated Fabrics*, 10, 26 - 34.

Keywords: 43,18,31,23,24,14,47,13,1,30,10,17,
THERMAL PROTECTION, FLAMMABILITY, MOLTEN METAL EXPOSURE,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES,
FABRIC CONSTRUCTION, WEARING COMFORT, F R WOOL (ZIRPRO),
ARAMID (NOMEX, KEVLAR), MISCELLANEOUS F R FIBERS, COTTON,
FIREFIGHTERS' PROTECTIVE CLOTHING,

(NO Copy on file)

Abstract:

Direct flame-firefighting - potential for injury both directly and by ignition of clothing.

Molten metal - can produce severe burns plus possible secondary ignition of clothing.

Inflammable liquid or gas ignited by spark - clothing should protect from direct flame and heat.

Clothing must not ignite or sustain combustion from exposure to direct flame or molten metal, must not melt away from the flame leaving a hole which exposes skin, must not melt to produce hot, sticky residues which stick to skin causing burns.

Clothing should prevent or restrict the transmission of heat through the fabric whether from direct flame, high radiant flux or molten metal. The fabric must remain intact under these conditions and form a strong, stable char to provide good insulation from the heat. The fabric should not shrink allowing the heat to come closer to the skin and molten metal shouldn't stick to the fabric which intensifies the heat flux.

The protective clothing must be comfortable, be capable of withstanding working conditions (soiling) and laundering requirements.

Fuel industries - clothing should not generate static electricity - a water repellent finish may be necessary to protect from spills or water mist or spray - in high radiant heat an aluminized coating may be necessary.

Wool - significant degree of FR in natural state, when Zirpro treated it gives good performance in primary functions of workwear but does not stand up well to frequent launderings and is not comfortable in warm, humid climates and hot, dirty and sticky working conditions.

Aramid - problems with shrinkage and hot residues. Low absorption so uncomfortable; problems with laundering and strength retention.

Flame-retardant synthetics - modacrylic - shrinks away from flame.

Polyester/Cotton - smartness, crease-retention and recovery, low cost - molten polymer; widely used in europe though potentially dangerous

FR Cotton - comfort, durability, launderability of natural cotton

Construction and fabric weight important against direct flame.

Fabric thickness important for molten metals - garment design to prevent entrapment of molten metal and to reduce direct garment/skin contact also important.

Chianta, M.A. & Stoll, A.M. (1964). Heat transfer in protection from flames. *Aerospace Medicine*, 35, 7 - 10.

Keywords: 23,38,18,16,30,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), SKIN SIMULANT, FLAMMABILITY, FABRIC SYSTEMS, MISCELLANEOUS F R FIBERS,

(Copy on file)

Abstract:

Chouinard, M.P., Knodel, D.C. & Arnold, H.W. (1973). Heat transfer from flammable fabrics. *Textile Research Journal*, 43(3), 166 - 175.

Keywords: 43,27,8,18,16,10,23,40,6,
THERMAL PROTECTION, MANNEQUINS, CLOTHING SYSTEMS, FLAMMABILITY, FABRIC SYSTEMS, COTTON, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), TESTING AND TEST METHODS, BURN INJURY,

(Copy on file)

Abstract:
An instrumented mannequin was constructed to measure the general heat transfer from single- and multi-layer garment systems after ignition by a flame source. A range of weights in fabrics of cotton, polyester/cotton, acrylic, wool, nylon and polyester has been studied.

Due in large measure to the melt-drip phenomenon, garments of polyester or nylon were found to burn relatively slowly over a limited area and self-extinguish, resulting in a little heat transfer to the mannequin. To supplement the mannequin data, an instrument was developed to record all modes of heat transfer, including that from melted polymer. This paper deals with its application to both single and double fabric layers.

Measurements were related to possible physiological effects, using data from the literature and a supplementary pathological study.

Conclusion:

While all common apparel textiles burn to some degree, large differences were found in their capacity to transfer epidermal tolerance to be exceeded over physiologically large surface areas on the mannequin. Heat transfer index was relatively moderate for wool because of the limited which produced low heat transfer. Nylon and polyester dresses presented a unique case. They burned slowly and self-extinguished before measurable energy reached the mannequin. These fabrics had a heat transfer index of zero. However, the melt-drip phenomenon which inhibits thermoplastic flame transmission was investigated to see if it produced localized energy-density transfer higher than that of nonmelting fabrics. The sensing board showed that no texted material transferred more average heat per unit weight than cotton. Although melted droplets of nylon and polyester contain considerable energy, the melt-drip process inhibited burning and heat generation to the extent that total transfer was suppressed. Less energy was transferred by burning polyester fabrics than any other types tested. The pathological study confirmed burning cotton, nylon or polyester fabrics can produce burns deeper than moderate second degree. The observed most severe effects were localized epidermal and dermal necrosis.

Consideration of all data from the mannequin, sensing board an pathological study leads to the conclusion that the fabrics of nylon, polyester, and wool had significantly lower heat-transfer capacity than the other materials studied.

Clark, J. (1972). Fire-resistant clothing supplement. London: Jim Clark Foundation, 1-20.

Keywords: 12,21
F R FINISHES, GARMENT DESIGN,

(NO Copy on file)

Abstract:

Clark, W. (1971). Heat transfer in bunker (turnout) coats. *Proceedings of a Symposium on Occupational Health and Hazards for the Fire Service*, 95.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Claus, W.D. Jr. (1973). Heat conduction in a two layer system with application to heat transfer to skin. *Journal of Fire and Flammability*, 4(1), 52 - 55.

Keywords: 43,18,16,6,23,8,
THERMAL PROTECTION, FLAMMABILITY, FABRIC SYSTEMS, BURN INJURY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), CLOTHING SYSTEMS,

(Copy on file)

Abstract:
Mathematical analysis.

Clifford, J.M. (1963). Requirements for the thermal control of a manikin for clothing investigation. *Industrial Medicine and Surgery*, 32, 40 - 43.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Clulow, E. & Rees, H.W. (1968). The transmission of heat through textile fabrics. *Journal of Textile Institute*, 59, 285 - 294.

Keywords: 40,23
TESTING AND TEST METHODS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:

Details are given of a new thermal-transmission apparatus which is automatic in operation, which does not depend on the measurement of a heat flux, and which requires no guard plates to eliminate edge heat losses.

The apparatus works on the principle that for conductors in series with respect to direction of heat flow, the ratio of the temperature drop across them equals the ratio of their thermal resistances, and the only measurements involved are those of temperature in the equilibrium state.

The apparatus is suitable for testing the thermal-transmission properties of timber and of plate glass determined with the new apparatus.

Clulow, E. (1984). Comfort indoors. Textile Horizons, 4(9), 20 - 22.

Keywords: 40,47,44,24,9,16
TESTING AND TEST METHODS, WEARING COMFORT, UNDERWEAR, INSULATIVE PROPERTIES, COMFORT ASSESSMENT, FABRIC SYSTEMS,

(Copy on file)

Abstract:
Textiles can contribute to indoor comfort in many ways via the window drapes, floor carpets and underlay and wall/ceiling insulation felts. Measurement of heat flows as in clothing indicates the effect of thermal resistance, makes possible accurate comparisons of these properties. Results of Togmeter tests on a range of thermal underwear fabrics are given in units called 'togs' which can equally apply to such items as quilts and quilted clothing. Perspiration transfer also effects comfort and is measured using the 'control dish method.' An I.C.I. Thermal Impression Meter was used to determine the 'cold feel' of many fabrics. Other physiological properties such as hairiness, static cling when damp and allergic reactions were reviewed.

Thickness is the most important property governing the thermal resistance of fabrics.

The product must also be pleasing aesthetically in order to keep us psychologically comfortable.

Coffin, D.R., Serad, G.A., Hicks, H.L., & Montgomery, R.T.. (1982). Properties and applications of Celanese PBI-polybenzimidazole fiber.. *Textile Research Journal*, 54, 516-521.

Keywords: 33,18,40,42,11
PBI, FLAMMABILITY, TESTING AND TEST METHODS,
THERMAL PROPERTIES OF F R FIBRES, DURABILITY OF F R FIBERS,

(NO Copy on file)

Abstract:

Coletta, G.C. et al. (1976). The development of criteria for firefighters' gloves, vol. 1: glove requirements. *NIOSH Publication 77-134-B.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Coletta, G.C., Arons, I.J., Ashley, L.E. & Drennan, A.P. (1976). The development of criteria for firefighters' gloves, vol. II: glove criteria and test methods. *NIOSH Technical Information.* Cincinnati, OH: U.S. Department of Health, Education and Welfare.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Colin, J., Timbal, J., Houdas, Y., Boutelier, C., & Guieu, J.D. (1971). Computation of mean body temperature from rectal and skin temperatures.. *Journal of Applied Physiology*, 31 (3), 484-489.

Keywords: 49
BODY TEMPERATURE MEASUREMENT,

(Copy on file)

Abstract:
The mean body temperature has been classically determined from a deep temperature Tde, the mean skin temperature, Tsk, and a coefficient x according to the following equation: Tb =x Tde + (1-x) Tsk. Some observations have pointed out that x could vary during body exposures to heat. Ninety-one experiments were made in five hot environments. The heat storages were directly determined from the evolution of the body mass variations. The best value for x in neutral (x!) and in hot (x) environments wer calculated by an optimization calculation using a computer. For all the subjects x! was 0.66 and x was 0.79. However, x varied more with the body heat storage than with the thermal load. For all the subjects it was found that x did not vary up to a heat storage of 113 kJ/m2, this value of x corresponding to x!. Above the heat storage of 113, the relation between x and the heat storage, Qs was: x = 17.0 x 10exp-4 Qs + 0.46.

Conciatori, A.B., Buckley, A. & Stuetz, D.E. (1983). PBI Fibers.. In M. Lewis & J. Preston (Eds.), *Handbook of Fiber Science and Technology Volume III High Technology Fibers Part A* (pp. 221-267). New York: Marcel Dekker In

Keywords: 33,23,18,43,40
PBI, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, THERMAL PROTECTION, TESTING AND TEST METHODS,

(NO Copy on file)

Abstract:

Coskren, R.J. (1973). Flame resistant and nonflammability textile fibers. *The Society for the Advancement of Material and Process Engineering*, 4(4), 13 - 19.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Coskren, R.J. & Kaswell, E.R. (1975). Development of pBI fabric for flight suit wear test. *AFML-TR-71-195.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Craig, F.N. & Cummings, E.G. (1962). Thermal influence of sunshine and clothing on men walking in humid heat. *Journal of Applied Physiology*, 17, 311 - 316.

Keywords: 9,41,47,
COMFORT ASSESSMENT, THERMAL / HEAT STRESS, WEARING COMFORT,

(Copy on file)

Abstract:
For two men walking on a treadmill and wearing two layers of permeable clothing, the same physiological strain measured by the rate of increase in mean body temperature could be produced: a) next to a building outdoors in the sunshine with an average air temperature of 85F and humidity of 20mm Hg and b) indoors with the same humidity and an air temperature 10F higher. Under these conditions, the underwear was mainly wet with sweat and the outer layer was mainly dry. In comparable indoors tests on a third subject, the temperature of the underwear approached equilibrium 1 or 2 F lower than the temperature of the skin at air temperatures of 85 and 115F. The error in calculating clothing insulation introduced by assuming the clothing to be dry is determined by the size and direction of the temperature gradient between skin and air. Adding 10F to the indoor air temperature does not duplicate all the effects of sunshine.

Craig, F.N. (1972). Evaporative cooling of men in wet clothing. *Journal of Applied Physiology*, 33, 331 - 336.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Crapnell, S. (1979). Hand and body protection: vital to safety success. *Occupational Hazards*, 41(2), 31 - 37.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Crown, E.M. (1985). Effect of garment design and construction on fire hazard potential of children's nightclothes. Ottawa: Consumer and Corporate Affairs Canada.

Keywords: 18,21,3,6,15,39,
FLAMMABILITY, GARMENT DESIGN, BEHAVIOUR AND ATTITUDES, BURN INJURY, FABRIC IGNITION TIME, SLEEPWEAR,

(Copy on file)

Abstract:

Cullis, C.F. & Hirschler, M.M. (1981). The combustion of organic polymers (International series of monographs on chemistry). New York: Oxford University Press.

Keywords: 18,6,
FLAMMABILITY, BURN INJURY,

(Copy on file)

Abstract:
CONTENTS

Chapter 1 - Organic Polymers
Chapter 2 - Polymer Combustion: Hazards
Chapter 3 - Polymer Combustion: Fundamental Studies
Chapter 4 - Polymer Combustion: Inhibition
Appendix - The Combustion Behaviour of Some Individual Polymers

Damon, A. et al. (1966). The human body in equipment design. Cambridge, Mass.: Howard University Press.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Day, M. & Sturgeon, P.Z. (1986). Water vapor transmission rates through textile materials as measured by differential scanning calorimetry. *Textile Research Journal*, 56(3), 157 - 161.

Keywords: 47,40,9,41,
WEARING COMFORT, TESTING AND TEST METHODS, COMFORT ASSESSMENT, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
The permeability of small textile samples to water vapor has been evaluated using a conventional DSC cell. The technique enables evaporative rate data to be determined and comparisons made of materials having different characteristics. The data are useful in predicting evaporative sweat loss rates, thereby helping to evaluate metabolic heat loss problems associated with protective clothing for firefighters.

de V. Martin, H. & Goldman, R.F. (1972). Comparison of physical, biophysical and physiological methods of evaluating the thermal stress associated with wearing protective clothing. *Ergonomics*, 15, 337 - 342.

Keywords: 29,8,40,27,5,47,41,9,
MILITARY PROTECTIVE CLOTHING, CLOTHING SYSTEMS, TESTING AND TEST METHODS, MANNEQUINS, BREATHING APPARATUS, WEARING COMFORT, THERMAL / HEAT STRESS, COMFORT ASSESSMENT,

(Copy on file)

Abstract:
Results from heated flat plate measurements of materials used in the standard U.S. combat uniform and in three different CW protective clothing ensembles (US and 1 UK) are compared to the insulation and evaporative heat transfer properties of the uniforms made from these materials as measured on a static heated copper manikin. The relative rank of these 4 uniforms, with and without M17 gas mask, with respect to heat stress imposed on soldiers working in a hot environment, and the body heat storage during a 3-5 mph treadmill march for 110 min. (50 min. march, 10 min. rest, etc.) in a climatic chamber at 35C, 50% RH with 3 mph wind were predicted from these static measurements. Physiological chamber trials were then conducted under the specified conditions with 8 volunteer subjects to evaluate the accuracy of the rank ordering and of the heat storage predictions. The results confirm the relative ranking with respect to heat stress of these uniform systems from the static measures. However, the actual measured mean values of heat storage wer substantially below those predicted from the static copper manikin insulation and evaporative impedance measures.

DeMartino, R.N. (1984). Comfort properties of polybenzimidazole fiber.. *Textile Research Journal*, 48, 314-319.

Keywords: 33,47,
PBI, WEARING COMFORT,

(NO Copy on file)

Abstract:

Derksen, W.L., Monahan, T.I. & DeLhery, G.P. (1961). The temperatures associated with radiant energy skin burns. *Temperature - Its Measurement and Control in Science and Industry*, 3(III), 171 - 175.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Disher, M. (1983). Quest for FR or a study of textile flammability. *Manufacturing Clothier*, 64(3), 39 - 51

Keywords:

(Copy NEVER VIEWED)

Abstract:

Problems of textile flammability and the development and use of flame-resistant fibers and fabrics are reviewed and discussed, particularly in relation to furnishings, clothing and protective garments. British Standards tests conducted by Shirley Institute are noted.

Dupont, H.B. (1960). How much heat can firemen endure?. *Fire Engineering*, (Feb.), 122.

Keywords: 43,18,5,47,23,22,6,
THERMAL PROTECTION, FLAMMABILITY, BREATHING APPARATUS, WEARING COMFORT, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), GLOVES, BURN INJURY,

(Copy on file)

Abstract:
Results of California Tests: Exposure to extreme heat for short durations had no ill effects. Little change in body temperature, large change in pulse. Best attributed to fear, nervous tension or heart responding to cool the body. Backs of hands, wrists first to suffer from heat. Cotton gloves found more comfortable than coated gloves.

Results of South Park Tests: No serious injuries or after effects noted in heat tests except blistered earlobes, backs of hands and across forehead. Men wearing self-contained or self-generating breathing apparatus reported comfortable breathing no matter how hot their bodies or clothing were.

Ebneth, H. & Fitzky, H.G. (1985). Metallized textile fabrics for microwave-Protective suits. *Journal of Industrial Fabrics*, 3(3), 36 - 42.

Keywords: 37,28,23
REGULATIONS AND STANDARDS, METALLIZED FABRICS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
The effects of microwave radiation on the human body and exposure limits recommended in West Germany and the USA are discussed. The use of Baymetex metallized fabrics in radiation-protective garments is described.

Einest, E.D. (1977). Laboratory test techniques for evaluating the thermal protection of materials when exposed to various heat sources. *AFML-TR-74-118.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Endrusick, T.L., Breckenridge, J.R. & Stroschein, L.A. (1985). An automated foot model to assess the heat transfer characteristics of protective footwear. *Proceedings of ACPTC Combined Central, Eastern and Western Regional Meetings*, 235.

Keywords: 43,23,24,27,36,40,18,29
THERMAL PROTECTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES, MANNEQUINS, PROTECTIVE FOOTWEAR, TESTING AND TEST METHODS, FLAMMABILITY, MILITARY PROTECTIVE CLOTHING,

(Copy on file)

Abstract:
An automated foot model was used to assess the insulative characteristics of protective footwear designed to be worn in an arctic environment. The model is an epoxy-filled copper shell, 0.32 cm (0.13 inches) thick, subdivided into twenty-seven separately heated and controlled measuring sections. Each test section is fitted with a heating element and from one to five thermistors embedded at designated locations.

Ernst, E.D.. (1977). Laboratory test techniques for evaluating the thermal protection of materials when exposed to various heat sources. AFML-TR-74-118.

Keywords: 40,42,43,23,16,18
TESTING AND TEST METHODS, THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FABRIC SYSTEMS, FLAMMABILITY,

(NO Copy on file)

Abstract:

Esch, V.H. (1976). Physiological hazards in fire-fighting as seen by a surgeon. *Conference on Protection for Fire Fighters*, ITT Research Institute, Chicago.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Fanger, P.O. (1972). Thermal comfort. New York: McGraw-Hill Book Co., 68 - 87.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Farnworth, B. & Dolhan, D.A. (1985). Heat and water transport through cotton and polypropylene underwear. *Textile Research Journal*, 55(10), 627 - 630.

Keywords: 44,47,10,41
UNDERWEAR, WEARING COMFORT, COTTON, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
Polypropylene is often hailed as a superior fiber for underwear for winter sports activities because of low water absorption and good wicking properties. Experiments performed on a sweating hot plate to try to discern any difference in heat loss through polypropylene and cotton underwear. Differences were noted but were too small to have any discernible influence on the thermal well-being of the wearer.

Finley, E.L., & Butts, C.T. (1974). Garment conformation on a mannequin changes flammable characteristics.. Source unknown.

Keywords: 4,6,8,10,12,14,16,18,21,27,40,
BLENDS, BURN INJURY, CLOTHING SYSTEMS, COTTON, F R FINISHES, FABRIC CONSTRUCTION, FABRIC SYSTEMS, FLAMMABILITY, GARMENT DESIGN, MANNEQUINS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
The conformation of the A-line dress on a fire-resistant mannequin was changed by tieing a self-fabric belt at the waist position. The dresses were made of light weight all-cotton fabric and cotton-polyester fabric in two blend levels. These experiments were conducted to obtain information on visual burning characteristics, maximum flame temperature and flame temperature-time relationship. the fabrics with and without flame-retardant finishes were tested on the mannequin before laundering. Those with flame-retardant finishes were also tested after laundering. The selected flame-retardant finishes included APO-THPC, THPC-MM-Urea and THPOH-NH3. The dresses were tested and flame temperature-time data were obtained, using the methods described in previous issues of This Journal.

Conformation of the dresses on the mannequin affected burning characteristics and flame temperature. Folds and gathers were formed by the belt at the waist position and mean flame temperature was higher for the belted-in dress than the A-line dress with no flame-retardant finish before laundering.

Conformation of the A-line dress produced higher flame temperature for the laundered A-line dress finished with THPOH-NH3. The belted-in dress was held closer to the mannequin. After the burning fabric was extinguished, the form of the dress remained on the mannequin as a layer of char which appeared to shield thermocouple points from flame.

Among fabrics, finished with THPOH-NH3, after laundering, flame temp;erature was higher for fabric with the higher polyester fiber content (50/50) than for the other two fabrics for both types of dress conformation.

The burning time was faster for the two fabrics containing polyester fiber than all-cotton fiber and between the two blends burning rate increased as the content of polyester fiber increased.

Fire Retardant Chemicals Association. (1984). *Progress in Fire Safety: Regulations, Polymers, Chemicals, Markets*.. Lancaster PA: Technomic Publishing Company, Inc.

Keywords: 40,18,23,37
TESTING AND TEST METHODS, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
REGULATIONS AND STANDARDS,

(NO Copy on file)

Abstract:
A new volume of reports from recent conferences of the Fire Retardant Chemicals Association (FRCA). The reports, by leading fire science and safety specialists, provide current information on a wide range of topics in this area.

Topics include fire testing, fire scenarios (what happens in fires), the fire behavior and fire retardance of products and materials, aspects of fire (such as smoke), fire regulations, codes and standards, and fire environments (such as buildings).

The authors of the reports are from companies, testing laboratories, consulting firms and government agencies. These include Underwriters Laboratories, National Bureau of Standards, National Institute of Building Sciences, and the Ontario Research Foundation.

The following is a more detailed look at the Reports contained in _Progress in Fire Safety_:

Part I: Progress in Fire Safety with Chemicals and Polymers

Overviews of Multiple Occupancy Fires. John G. Degenkolb, Fire Protection Engineers & Building Code Consultants.

Small Scale Smoke Testing. Charles J. Sparkes, Arapahoe Chemicals, Inc.

Large Scale Smoke Testing. James R. Beyries, Underwriters Laboratories, Inc.

An Assessment of Correlations Between Laboratory and Full-Scale Experiments for the FAA Aircraft Fire Safety Program, Part 1: Smoke. James G. Quintiere, Centre for Fire Research, National Bureau of Standards.

The Structural Systems Approach--Smoke. C.F. Baldassarra, Schirmer Engineering.

Risk Assessment. Gordon T. Thomas, CPCU, TRMC, Inc.

Tests and Controls to Limit the Fire Risks of the Controls of Buildings and Contents of Buildings. K.T. Paul, RAPRA, UK.

Smoke vs. Fire Hazard. Frederic B. Clarke III, Benjamin/Clarke Associates, Inc.

_Part II : Fire Safety Regulations and Their Markets - The United States and

Canada_

The Building Code Situation in the U.S. Robert Dillon, National Institute of Building Sciences.

Flammability Regulations and the Hazardous Products Act. Dr. R. Viau, Chief, Flammability Hazards Division, Consumer and Corporate Affairs.

International FR Textile Standards, Michael Williams, Ontario Research Foundation.

Military Market for Fire Retardant Textile Materials in Canada. Donald A. Watkins, Federal Dept. of National Defense.

U.S. Navy Battle Dress Program. Norman F. Audet, U.S. Navy Clothing and Textile Research Facility.

Behaviour of Cables Under Fir Conditions. Marco Barbaro-Forleo, Pirelli Cables, Inc.

A Fire Study of Cellulose Plastics Insulation in Cavity Walls. William Taylor, Esso Chemical, Canada.

Fishbein, M. & Ajzen, I. (1975). Belief, attitudes, intention and behavior: an introduction to theory and research. Reading, Mass.: Addison-Wesley.

Keywords: 3
BEHAVIOUR AND ATTITUDES,

(NO Copy on file)

Abstract:

Fonseca, G.F. (1970). Heat-Transfer properties of ten underwear-Outerwear ensembles. *Textile Research Journal*, 40, 553 - 558.

Keywords: 44,41,23,8,47,24,
UNDERWEAR, THERMAL / HEAT STRESS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), CLOTHING SYSTEMS,
WEARING COMFORT, INSULATIVE PROPERTIES,

(NO Copy on file)

Abstract:
The heat transfer properties of ten underwear-outerwear ensembles were determined in the laboratory by using a heated "sweating" sectional manikin. Theoretically, by applying the im theory to these results, a Nomex underwear-Nomex outerwear ensemble showed a slightly greater environmental range. However, little differences were found in the individual clo or im clo values among the underwear combinations. The results for two ensembles having the same underwear but different outerwear indicated that the outerwear could be the deciding factor in determining the thermal characteristics of complete clothing ensembles. It appears that underwear per se merely occupies a portion of the still air layer, and, therefore, the nature of underwear has little to do with the overall thermal insulation, although these results may be independant of subjective comfort.

Fornell, D. (1970). Engineer your turnout coats for safety. *Fire Chief Magazine*, 14, 37.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Fourt, L. & Hollies, N.R.S. (1970). Clothing: comfort and function. New York: Marcel Dekker.

Keywords: 21,8,47,41,46,
GARMENT DESIGN, CLOTHING SYSTEMS, WEARING COMFORT, THERMAL / HEAT STRESS, WEAR STUDY METHODS,

(Copy on file)

Abstract:
CONTENTS

1. Factors Involved in the Study of Clothing
2. Clothing Considered as a System Interacting with the Body
3. Clothing Considered as a Structured Assemblage of Materials
4. Heat and Moisture Relations in Clothingj
5. Physiological and Field Testing of Clothing by Wearing It
6. Physical Properties oof Clothing and Clothing Materials in Relation to Comfort
7. Differences Between Fibers with Respect to Comfort
8. Current Trends and New Developments in the Study of Clothing

Fourt, L. & Hollies, N.R.S. (1971). Improvement of firemen's turnout coats for greater comfort and effectiveness in work. Final Report on Contract National Bureau of Standards(1).

Keywords:

(Copy NEVER VIEWED)

Abstract:

Fourt, L., Hollies, N.R., & Utech, H.P.. (1974). The firefighter's turnout coat: a design analysis.. *Journal of Safety Research*. 6(1), 2-13.

Keywords: 8,17,21
CLOTHING SYSTEMS, FIREFIGHTERS' PROTECTIVE CLOTHING, GARMENT DESIGN,

(NO Copy on file)

Abstract:

Freeston, W.D. (1971). Flammability and heat transfer characteristics of cotton, nomex and PBI fabric. *Journal of Fire and Flammability*, 2, 57 - 76.

Keywords: 6,1,10,33,23,11,35,15,18,42,43,
BURN INJURY, ARAMID (NOMEX, KEVLAR), COTTON, PBI,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS,
FABRIC IGNITION TIME, FLAMMABILITY, THERMAL PROPERTIES OF F R FIBRES,
THERMAL PROTECTION,

(Copy on file)

Abstract:
The ignition temperatures and burning rates in air of similar PBI, Nomex and flame-retardant-treated cotton fabrics are given and the thermal shrinkage of PBI and Nomex fabric are compared. The thermal conductivity of a series of fabrics at ambient and elevated temperatures is given. The temperature rise in a fabric-covered skin simulant under flame impingement is investigated for a range of fabric constructions. The flame-impingment heat transfer experimental data are compared with theoretically predicted results. A parametric study of the material properties which govern heat transfer through a fabric under flame impingement is presented. The results indicate that one type of fibrous structure which will provide improved thermal protection is moderate weight, tightly woven PBI fabric over a PBI tricot mesh.

Freeston, W.D. et al. (1971). Flammability and heat transfer characteristics of pBI fabric. *AFML-TR-70-267.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Frieder, L.P. (1967). Aluminized clothing - comments. *Firemen*, (April) 34.

Keywords: 43,18,17,11,28,35,23,24,41,47,
THERMAL PROTECTION, FLAMMABILITY, FIREFIGHTERS' PROTECTIVE CLOTHING,
DURABILITY OF F R FIBERS, METALLIZED FABRICS,
PHYSICAL PROPERTIES OF F R FIBERS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES,
THERMAL / HEAT STRESS, WEARING COMFORT,

(Copy on file)

Abstract:

Two kinds of heat in fire environment: radiant - can be shielded by any object or reflected by reflective surface of protective garments and hot air-heat from hot air transmitted to garment so need heavy layer of insulating material behind reflective cloth.

Heat reflectivity should be about 95% so only 5% of heat will heat outer surface of garment.

Aluminum film can be vacuum deposited on rubber or Mylar - Mylar more durable

Dirt and abrasion reduce reflectivity of aluminum - Mylar more resistant to cleaning.

Abrasion resistance also better as rubber is deformed or elongated as cloth is creased, folded or rubbed.

If the layer behind aluminum can absorb heat, then 5% of heat not reflected is delayed in heating the layer - asbestos best, the heavier the more it can absorb, if neoprene coated the heat absorption qualities are enhanced; glass second best - high tensile strength; backing of black neoprene improves heat absorption; rayon next - must be flame-retardant treated - water will decrease flame retardancy

Fire Entry Suits - often wool or rabbit hair used a sheet insulator. - give off odor when heated so need second air-impervious layer on inside to prevent gases contacting skin - often glass fabric coated on both sides with neoprene.

Frim, J. (1985). Research proposal for a study of metabolic heat buildup in firefighters. Defence and Civil Institute of Environmental Medicine.

Keywords: 41,45,17,29,40,46,
THERMAL / HEAT STRESS, VAPOUR BARRIERS, FIREFIGHTERS' PROTECTIVE CLOTHING, MILITARY PROTECTIVE CLOTHING, TESTING AND TEST METHODS, WEAR STUDY METHODS,

(Copy on file)

Abstract:

Much of the improved protection is aimed at guarding against burns of one sort or another and generally involves the addition of extra insulation to the clothing as well as a closing up of "holes" in the garment system. New bunker style clothing is effective in protecting the firefighter from many environmental hazards; it also interferes with the dissipation of metabolic heat from the body.

Vapour barrier - one proposed solution to these conflicting requirements for water transport involves replacing the vapour barrier with a "breathable" fabric such as GORETEX.

GORETEX and other similar products are supposed to be effective wind and water barriers while still allowing water vapour to pass freely through the clothing.

An approach is to eliminate the vapour barrier from some regions of the clothing where it may not be needed (a partial barrier).

3 phases of testing suggested:

Phase I - field study involving actual fires or during simulations and training at a firefighter training center

Phase II - selecting a set of laboratory tasks and test protocols which simulate aspects of firefighting duties in terms of energy expenditure and type of work, and then performing experiments under controlled conditions tro analyze the physiological responses of the body to these tasks while wearing various types of firefighting clothing.

Phase III - returning to the field for verification of phase II

Fuzek, J.F. & Ammons, R.L. (1977). Techniques for the subjective assessment of comfort in fabrics and garments. In N.R.S. Hollies & R.F. Goldman (Eds.), *Clothing Comfort* (pp. 121 - 130). Ann Arbor, MI: Ann Arbor Science.

Keywords: 47,3,9,46,
WEARING COMFORT, BEHAVIOUR AND ATTITUDES, COMFORT ASSESSMENT, WEAR STUDY METHODS,

(Copy on file)

Abstract:
Comfort is a subjective phenomenon, difficult to measure by objective approaches. Used two statistical methods - the random block design and Scheffe's (1952) paired comparison method - for the subjective evaluation of comfort. When selecting participants it is essential that the participant normally wear the type of garment being evaluated. Participant should be voluntary. Try to control color, garment fit and design, garment dimensional stability, fabric weight and thickness, and hand so all garments are as close in these respects as possible. The end discusses an actual wear test and the results and procedure of this wear test.

Gagge, A.D. & Nishi, Y. (1977). Heat exchange between human skin surface and thermal environment. In D.H.K. Lee (Ed.) *Handbook of Physiology* (Section 9). Bethesda: American Physiological Society.

Keywords: 6,47,41,
BURN INJURY, WEARING COMFORT, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
CHAPTER CONTENTS

Body Heat Balance Equations; Independent Variable in Human Thermal Environment (Ambient temperature, Dew-point temperature or ambient vapor pressure, Air and fluid movement, Mean radiant temperature or effective radiant field, Clothing insulation, Barometric pressure, Time of exposure); Dependent Physiological Variables in Body Heat Balance Equation (Mean skin temperature, Skin wettedness, Body heat storage and rate of change of mean body temperature, Metabolic energy); Sensible Heat Exchange by Radiation and Convection (Operative temperature, Clothing in sensible heat exchange); Radiation Exchange (Mean radiant temperature and effective radiant field, Direct evaluation of effective radiant field, solar radiation, measurement of radiation exchange); Convective Heat Exchange (Heat transfer theory, Free and force convection, Measurement of convective heat transfer coefficient, Effect of barometric pressure); Evaporative Heat Exchange (Direct measurement of evaporative heat loss, Maximum evaporative heat loss from skin surface, The Lewis Relation between heat and mass transfer coefficients, Skin wettedness vs. efficiency of evaporative regulation); Special Environments (Water immersion, Hyperbaric helium-oxygen atmospheres); Rational Temperature Indices of Thermal Environment (Operative temperature, Humid operative temperature, Standard operative temperature, Standard humid operative temperature, Standard effective temperature, A new effective temperature index); Summary

Gardella, J.W. & Wohrer, L.C. (1973). Textile and flammability properties of kynol blends. *Proceedings of the 1973 Symposium on Textile Flammability.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Garrett, E.L. (1978). Ceramic fibre materials for fire protection. *Insulation*, 22(2), 6 - 9.

Keywords:

(Copy NEVER VIEWED)

Abstract:

George, M.F. (1983). Gas-Tight suits - the way to complete protection?. *Fire Engineers Journal*, 43(130), 37 - 38.

Keywords: 45,17,21
VAPOUR BARRIERS, FIREFIGHTERS' PROTECTIVE CLOTHING, GARMENT DESIGN,

(Copy on file)

Abstract:
The total protection or coverall suit is a new concept and as such it deserves careful analysis. In this article, Mr. M.F. George, MIFireE, undertakes a thoughtful discussion of the advantages and the possible drawbacks of this type of design. Mr. George is an ADO with the West Midlands Fire Service.

Giether, W.F. (1973). Human performance at elevated environmental temperatures. *Aerospace Medicine*, 44(7), 747 - 755.

Keywords: 41
THERMAL / HEAT STRESS,

(NO Copy on file)

Abstract:
A review of research on human performance at elevated temperatures is presented. the findings are analyzed in terms of five categories of performance measurements: 1) time estimations, 2) reaction time, 3) vigilance and monitoring, 4) tracking and 5) cognitive and other skilled tasks. Time estimation studies, requiring subjects to count or tap at specified rates, generally show increased speed as either body or environmental temperatures are experimentally increased. Presumably both of these effects are a reflection of increased speed of neural conduction. Improvements in performance have also been found in measurements of vigilance, with optimumn performance appearing at an Effective Temperature (ET) of about 80F. For all other performance functions there appears to be a plateau, with only minor effects, up to an ET of about 85F. As environmental temperatures exceed this value there are generally encreasing performance decrements. This plateau up to 85F ET appears to coincide very closely to the range over which the human body can compensate physiologically to elevated environmental temperatures.

48 refs.

Gilling, D.R. & Streets, D.F. (1969). Comparative physiological trial on garments for firefighting. *Army Personnel Research Establishment Report No. 3/69.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Givoni, B. & Goldman, R.F. (1971). Predicting metabolic energy cost. *Journal of Applied Physiology, 30(3), 429 - 433.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Goldman, R.F. (1963). Tolerance time for working in the heat when wearing cBR protective clothing. *Mil. Med.*, 128, 776 - 786.

Keywords: 41, 21, 47,
THERMAL / HEAT STRESS, GARMENT DESIGN, WEARING COMFORT,

(NO Copy on file)

Abstract:

Goldman, R.F., Green, E.D. & Iampietro, P.F. (1965). Tolerance of hot wet environments by resting man. *Journal of Applied Physiology*, 20, 271 - 277.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Goldman, R.F. (1972). Evaluation of firemen's turnout coats for national bureau of standards. U.S. Army Natick Laboratories Memorandum No. MEDRIME.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Goldman, R.F. (1973). Clothing, its physiological effects, adequacy in extreme environments and possibility of future improvements. *Arch. Sci. Physiol.*, 27.

Keywords: 21,41,23,
GARMENT DESIGN, THERMAL / HEAT STRESS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(NO Copy on file)

Abstract:

Goldman, R.F. (1974). Clothing design for comfort and work performance in extreme thermal environments. *Transactions of the New York Academy of Science*, 36, 531 - 544.

Keywords: 23, 40, 27, 41, 1, 10, 21,45,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
TESTING AND TEST METHODS, MANNEQUINS, THERMAL / HEAT STRESS,
ARAMID (NOMEX, KEVLAR), COTTON, GARMENT DESIGN, VAPOUR BARRIERS,

(NO Copy on file)

Abstract:
5 levels of analysis used: 1) Physical heat transfer characteristics measured by use of heated flat plate theory and also a unique sweating flat plate; 2) complete clothing ensembles, with and without additional gear, are evaluated on a sweating copper manikin for heat transfer characteristics; 3) carefully controlled physiological trials carried out in climatic chanbers with volunteers dressed in clothing ensembles, to computer-predicted tolerance levels; 4) controlled, small-scale studies are conducted in the field or at work site; 5) studies with the clothing systems are carried out during actual field operations.

Suggest that impermeable garments be fitted with permeable patches in selected areas to increase heat dissipation.

Tested either one or two layers of new Nomex fiber against a standard cotton fatigue and a standard cotton tropical combat uniform. Two layer Nomex had a high clo value and higher heat storage value than the others.

Physiologic evaluation showed significant advantage of a vent in the impermeable raincoat fabric but no advantage in the permeable coat. Billowing impermeable garments - ponchos - had average heat storage really as low as vented impermeable garment.

Combined use of clo and im/clo as measured on heated, sweating copper manikins is valuable when predicting a rank order of thermal stress effects for clothing ensembles worn in the heat. Care must be taken if air permeabilities differ widely or if clothing design allows unusual air exchange during subject motion.

Goldman, R.F. (1977). Thermal comfort factors: concepts and definitions. In N.R.S. Hollies and R.F. Goldman (Eds.) *Clothing Comfort* (pp. 3 - 8). Ann Arbor, MI: Ann Arbor Sciences.

Keywords: 9,23,47,40,
COMFORT ASSESSMENT, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), WEARING COMFORT, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Four factors in the ambient environment which affect our comfort or discomfor in clothing. First of these, the air temperature, second evaporation of sweat, thirdly the wind velocity and lastly the thermal radiation that is exchanged between the skin surface and the ambient radiant surround, as a function of surface temperature differences. These four factors, the dry bulb or air temperature (Tdb or Ta), wet bulb temperature (Twb) which can be converted to vapor pressure, wind velocity and globe temperature (Tg), from which mean radiant temperature can be derived, are the essential elements in determining whether or not a given environment will be comfortable.

Graves, K.W. (1970). Firefighters exposure study. *Aircraft Ground Fire Suppression and Rescue Suppression and Rescue SPO Report.* Dayton, Ohio: Wright Patterson Air Force Base.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Griffin, et al (1978). Welding processes. New York: Van Nostrand Reinhold Company.

Keywords: 48,43,22,31,23,6,
WELDERS' PROTECTIVE CLOTHING, THERMAL PROTECTION, GLOVES,
MOLTEN METAL EXPOSURE, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
BURN INJURY,

(NO Copy on file)

Abstract:
Basic Oxyacetylene Welding:
Hazards:
1) The welding flame and sparks coming from the molten puddle can cause flammable material to ignite on contact. FR clothing must be worn and hair protected. Welding and cutting should not be done near flammable materials i.e. wood.
2) In addition to the risk of eye injury from flying molten metal, there is also the danger of radiation burns due to the infrared rays given off by hot metals. The eyes may be burned if these rays are not filtered out by proper lenses. The eyes should be protected at all times by approved safety glasses and the proper shield. Sunglasses are not adequate.
3) Fluxes used in certain welding and brazing operations produce fumes which are irritating to the eyes, nose, throat and lungs. Likewise, the fumes produced by overheating lead, zinc, cadmium are a definite health hazard when inhaled even in small quantities. The oxides produced by these elements are poisonous. Welding area should be well ventilated. The operator shouldn't expose others to fumes produced in welding.

Haisman, M.F. (1977). Physiological aspects of protective clothing for military personnel. In N.R.S. Hollies and R.F. Goldman (Eds.) *Clothing Comfort* (pp. 9 - 18). Ann Arbor, MI: Ann Arbor Sciences.

Keywords: 29,47,41,21,
MILITARY PROTECTIVE CLOTHING, WEARING COMFORT, THERMAL / HEAT STRESS, GARMENT DESIGN,

(Copy on file)

Abstract:
Main objective of research into military protective clothing is to help the designers, developers and procurers provide military personnel with the clothing and personal equipment most appropriate for their task. The day-to-day work is to assess the physiological effects of the various clothing systems in terms of thermal balance, sweat loss, heart rate and energy expenditure. Topics from the APRE physiological work program have been received, namely cold weather clothing, tropical clothing, electrically heated clothing and finally body almol. These topics all relate to the problems of comfort within protective clothing systems.

Harder, C.A., Held, B.J., and Cardenas, G.J. (0000). Breathing apparatus part III, Operation of self-contained breathing apparatus exposed to high temperatures.. Source Unknown.

Keywords:

(Copy on file)

Abstract:
The authors of this paper believe that protective gear of fire fighters i should not only help them fight routine fires in safety and comfort, but i should give them the protection they need for hazardous rescues or for such i unforseen emergencies as flare-ups. Their studies evaluated existing i equipment so that it may be selected from devices that offer the best i protection possible. Test parameters and criteria were developed to evaluate i the various makes and models of self-contained breathing apparatus. They i present the results of the tests conducted in this paper.

Hardy, J.D., & DuBois, E.F. (1938). Basal metabolism, radiation, convection and vaporization at temperatures of 22 to 35 C.. *The Journal of Nutrition*, 15(5), 477-497.

Keywords: 40
TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Hardy, J.D., & DuBois, E.F. (1938). The technic of measuring radiation and convection.. *Journal of Nutrition*, 15(5), 461-475.

Keywords: 49,23,9,47
BODY TEMPERATURE MEASUREMENT,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), COMFORT ASSESSMENT,
WEARING COMFORT,

(Copy on file)

Abstract:
The total radiation from the surface of the human body can be determined by means of the Hardy radiometer making due allowance for the effective radiating surface which is smaller than the total surface. The respiration calorimeter of the Russell Sage Institute of Pathology in one set of measurements determines the heat lost in vaporization. By an independent method it gives accurate figures for the heat lost in radiation plus convection. This makes it possible to determine by subtraction the heat loss by convection and to partition the three important channels of heat loss. Inasmuch as calculations are based on heat loss and not heat production the heat storage in the body is not employed in determining partition of heat loss. It can be calculated from the difference in heat production and heat loss.

It is believed that the combination of respiration calorimeter and radiometer has provided the first accurate measurement of normal convection loss.

Harmathy, T. (1985). Fire safety: science and engineering. *STP 882: ASTM Special Technical Publication.*

Keywords: 37,18,40,6,43,
REGULATIONS AND STANDARDS, FLAMMABILITY, TESTING AND TEST METHODS, BURN INJURY, THERMAL PROTECTION,

(NO Copy on file)

Abstract:
CONTENTS

The Potential of Scientifically Based Fire Protection Engineering; Fire Performance Standards for Buildings; Fire Risk Assessment: Integrating Fire Testing and Fire Codes; Standard Room Fire Test Development at the National Bureau of Standards; Combustible Linings and Room Fire Growth - A First Analysis; Future Directions for Modeling the Spread of Fire, Smoke, and Toxic Gases; Scaling Correlations of Flashover Experiments; Stochastic Modelling of Fire Growth; Application of the Standard Fire Curve for Expressing Natural Fires for Design Purposes; Design of Buildings for Prescribed Levels of Structural Fire Safety; Fire Performance of Reinforced Concrete Columns; Effect of Fire Exposure on Structural Response and Fireproofing Requirements of Structural Steel Frame Assemblies; Computer Modeling the Fire Endurance of Floor Systems in Steel-Framed Buildings; New Concepts for Measuring Flame Spread Properties; Prediction of Upholstered Chair Heat Release Rates from Bench-Scale Measurements; Smoke Production in Fires: Small-Scale Experiments; Control Safety Considerations for HVAC Smoke Management Techniques; The Need and Availability of Test Methods for Measuring the Smoke Leakage Characteristics of Door Assemblies; An Evaluation of Toxic Hazards from Full-Scale Furnished Room Fire Studies; Applications of Sprinkler Technology - Early Suppression of High-Challenge Fires with Fast-Response Sprinkler; Definition of the Concentration Gradient Above Flammable Liquids; The Human Aspects of Fires in Buildings - A Review of Research in the United Kingdom.

Harnett, P. (1984). Functions and properties of 'Thermal' underwear. *Wool Science Review*(60), 3 - 11.

Keywords: 44,47,
UNDERWEAR, WEARING COMFORT,

(NO Copy on file)

Abstract:
Factors involved in the construction of underwear with good 'thermal comfort' properties (satisfactory ability to retain body heat in combination with minimal restriction of perspiration vapour flow away from the body) are explained and discussed. The importance of 'mechanical comfort' (performance and body conformation of garments during physical activity) is also noted.

Henane, R., Bittel, J., Vivet, R. & Morino, S. (1979). Thermal strain resulting from protective clothing of an armored vehicle crew in warm conditions. *Aviation, Space and Environmental Medicine*, 50, 599 - 603.

Keywords: 41,29,47,
THERMAL / HEAT STRESS, MILITARY PROTECTIVE CLOTHING, WEARING COMFORT,

(Copy on file)

Abstract:
The purpose of the study is to define a method of evaluation of physiological strain resulting from protective garments worn in warm conditions by the armored vehicle crew. A technique is developed evaluating evaporative transfer through clothing by continuous weighing of the active man (accuracy +/-3/g). An index is defined (Iw) as the ratio of steady-state evaporative rate in clothed conditions to steady-state evaporative rate of nude subject in the same conditions of work and heat stress. The Iw index is significantly related to physiological strain determined by increased body heat content and reduced tolerance time. The results are compared to other previous findings concerning evaporative transfer through clothing and physiological strain indexes. The technique shows that evaporation through heavy clothing is not negligible. It is suggested that usual static measurements using physical models underestimate the evaporative heat transfer through clothing layers.

Henriques, F.C. Jr., & Moritz, A.R. (1947). Studies of thermal injury i: the conduction of heat to and through skin and the temperatures attained therein - a theoretical and experimental investigation. *American Journal of Pathology*, 23, 531 - 549.

Keywords: 23,43,6,40
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, BURN INJURY, TESTING AND TEST METHODS,

(NO Copy on file)

Abstract:

Conduction - heat absorbed by skin depends on the properties of the heat absorber (skin).

Convection and Radiation - uptake of heat by skin determined by the heat source.

Rate of temperature rise within skin depends on: 1) heat capacity of skin (ability to absorb heat) and 2) thermal conductivity of the skin (ability to transport heat)

Summary: The various physical factors which determine the transfer of heat energy to and through the skin and the temperatures attained therby have been defined and discussed. A general theory of heat flow, which enabled the estimation of the time-temperature relationships within the epidermis during exposure to heat, was developed.

The thermal conductivities and heat capacities of epidermis, dermis and subcutaneous fat and muscle were measured in vitro.

Experimental observations pertaining to the rate at whcih thermal energy is taken up by the skin, during surface exposures of varying intensity, and the sub-surface thermal gradients established therein, have been presented.

The time-temperature relationship at the dermal-epidermal junction was computed under two greatly different experimental conditions: 10 when the skin surface temperature was immediately brought to, and maintained at, the temperature of the heat source, and 2) when the entire skin surface was exposed to specified circumambient and circumradiant temperatures. These data indicate the extreme importance of the mode of applying heat to the skin surface in the time-temperature relationships within epidermis.

Henriques, F.C. Jr. (1947). Studies of thermal injury vs. the predictability and the significance of thermally induced rate processes leading to irreversible epidermal injury. *Archives of Pathology*, 43(5), 489 - 502.

Keywords: 6,41
BURN INJURY, THERMAL / HEAT STRESS,

(NO Copy on file)

Abstract:
The experimental time-temperature relationships which determine the thresholds of epidermal injury (studies II and IV of "Studies of Thermal Injury") are subjected to mathematical analysis. Two types of thermal exposure are considered: those in which the cutaneous surface is immediately brought to and maintained at a constant temperature and those in which the skin is exposed to a constant source of circumambient and circumradiant heat.

It is demonstrated that all of these data are quantitatively predicted by an equation. A theoretic treatment of this equation shows that, of all the physical and chemical processes known to date, thermally induced epidermal injury must be due primarily to thermal changes of those proteins and enzymes whose rate of alteration corresponds to an activation energy of at least 150 kilocalories per mol and an entropy change of about 395 units. This is consistent with the known existence of a reversible phase of latent epidermal injury.

Heskestad, G. (1973). Ease of ignition of fabrics exposed to flaming heat sources. Norwood, Mass.: Factory Mutual Research Corp.

Keywords: 40,15,18
TESTING AND TEST METHODS, FABRIC IGNITION TIME, FLAMMABILITY,

(Copy on file)

Abstract:
The ease of ignition of fabrics exposed to flames was studied. Ignition or melting times were at a minimum close to the luminous tip of diffusion and to the tip of the inner cone of premixed flames. These minimum ignition times were found to be insensitive to fabric orientation, burner tube diameter, and flame height but varied appreciably for diffusion and premised flames. With the exception of fabrics with prominent surface structures, (eg. terry cloth), ranking of fabrics by ignition and melting times would be preserved through a large number of exposure modes. A simple theoretical model, which considers the fabric to be impervious and inert, to possess a unique ignition temperature and to be heated soully by convection, is consistent with the experimental findings.

Hill, B.J. (1976). Flame-Resistant fibers and fabrics - a review of the work at hambeg industrial research association. *Fire and Materials*, 1(2), 52 - 56.

Keywords: 18,12,40,
FLAMMABILITY, F R FINISHES, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
This paper discusses the relative merits of a number of flame-resistant fabrics. The information quoted draws from a five year program of research carried out on the subject by Lambeg Industrial Research Association. The fabrics concerned were either made from flame-resistant fibres or by flame-resistant treatment of fabrics. The textile problems which can arise in the production of these fabrics are considered and means of avoiding them suggested. Test methods for flammability are discussed and the subject of toxic gases generated from flame-resistant materials in fire situations is introduced.

Hillermeier, K. (1983). Fiber subtitutes for asbestos. *Textile Month*, (Sept.).

Keywords: 2, 1,30,47,11,35,
ASBESTOS, ARAMID (NOMEX, KEVLAR), MISCELLANEOUS F R FIBERS, WEARING COMFORT, DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS,

(NO Copy on file)

Abstract:
This author compares the tenacity and tensile modulus, thermal and chemical resistance of asbestos with that of potential substitutes such as aramids, carbon fibers, glass and ceramic fibers. Comparison of textile properties indicates that only the organic aramid fibers are superior to asbestos in handling, flexing, abrasion and compatability with the human skin. In the area of processability aramids were found to be superior to inorganic fibers and more suited to high speed processing. A review is made of applications such as friction materials (clutches), seals (gaskets, packing materials) and heat protective clothing. Three graphs provide comparative data and support the conclusion that asbestos substitute fibers should be selected based on their capacity to replace the simplest alternative material.

Hoge, H.J. & Fonseca, G.F. (1964). The thermal conductivity of a multilayer sample of underwear material under a variety of experimental conditions.. *Textile Research Journal*, 34(5), 401 - 410.

Keywords: 44,8,16,10,47,40,23
UNDERWEAR, CLOTHING SYSTEMS, FABRIC SYSTEMS, COTTON, WEARING COMFORT, TESTING AND TEST METHODS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
Results of measurements of the thermal conductivity of a sample of twelve layers of standard underwear material (50% wool, 50% cotton) are presented. Temperature was varied from about 65F to about 135F, pressure (air) was varied from less than 0.1 mm Hg to atmospheric, and sample density was varied from about 14 to about 20 lb/ft3. Some measurements were made with the air removed from the sample chamber and water introduced. Measurements were also made with the air in the sample chamber replaced by helium or by Freon-12 (CCl2F2). All measurements were made on the same sample, under carefully controlled conditions. Therefore these data should have greater validity than results obtained in different apparatuses under varying conditions. The reported values are believed to be accurate to +/- 2%.

Holcombe, B.V. (1983). Heat-Related properties of protective clothing fabrics. *Fire Safety Journal*, 6(2), 129 - 141.

Keywords: 43,16,8,10,1,13,26,2,30,23,18,15,41,
THERMAL PROTECTION, FABRIC SYSTEMS, CLOTHING SYSTEMS, COTTON, ARAMID (NOMEX, KEVLAR), F R WOOL (ZIRPRO), LEATHER, ASBESTOS, MISCELLANEOUS F R FIBERS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, FABRIC IGNITION TIME, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
In a study of 56 fabrics or fabric assemblies suitable for use as firefighters' protective clothing (types examined included cotton/cellulosic, aramid, wool, leather, asbestos, glass fibre and ceramic fibre), measurements were made of resistance to intense radiant heat and intense convective heat, ease of ignition, and resistance to loss of body heat. The primary factor influencing the resistance to radiant heat, convective heat and loss of body heat was shown to be the material thickness rather than the fibre type. In the ease-of-ignition tests, all the materials were severely degraded in the flame contact area.

Hollies, N.R.S. & Goldman, R.F. (1977). Clothing comfort. Ann Arbor, MI: Ann Arbor Sciences.

Keywords: 47,9,23,43,10,21,41,
WEARING COMFORT, COMFORT ASSESSMENT,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION,
COTTON, GARMENT DESIGN, THERMAL / HEAT STRESS,

(NO Copy on file)

Abstract:
CONTENTS

SECTION I: Thermal Balance and Protection Against the Environment
1. Thermal Comfort Factors: Concepts and Definitions (R.F. Goldman)
2. Physiological Aspects of Protective Clothing for Military Personnel (M.F. Haisman)
3. The Use of an Acoustic Test to Predict Fabric Comfort Properties (S.M.A. Fahmy and K. Slater)

SECTION II: Fiber and Fabric Properties in Relation to Comfort
4. Comfort finishing of Synthetic Fabrics (B.M. Latta)
5. Increased Recovery in Knitted Cotton and Cotton Blends with Comfort Stretch (B.A. Kottes Andrews, G.B. Verburg, A.B. Cooper and J.G. Frick, Jr.)
6. Partial Analysis of Comfort's Gestalt (G.J. Pontrelli)

SECTION III: Comfort Sensation and Assessment in Clothing Fabrics
7. Psychophysical and Neurophysiological Studies of Tactile Sensibility (R.H. LaMotte)
8. Psychological Scaling in Comfort Assessment (N.R.S. Hollies)
9. Techniques for the Subjective Assessment of Comfort in Fabrics and Garments (J.F. Fuzek and R.L. Ammons)

SECTION IV: Interaction of Clothing and Environment and the Ventilation of Clothing from Body Motion
10. The Psychrometric Range of Clothing Systems (J.H. Mecheels and K.H. Umbach)
11. Effects of Body Motion on Convective and Evaporative Heat Exchanges Through Various Designs of Clothing (J.R. Breckenridge)

Hollies, N.R.S. & Goldman, R.F. (1977). Clothing comfort: interaction of thermal, ventilation, construction and assessment factors. Ann Arbor, Mich.: Ann Arbor Science.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Hollies, N.R.S. (1977). Psychological scaling in comfort assessment. In N.R.S. Hollies and R.F. Goldman (Eds.) *Clothing Comfort* (pp. 107 - 120). Ann Arbor, MI: Ann Arbor Sciences.

Keywords: 21,3,9,47
GARMENT DESIGN, BEHAVIOUR AND ATTITUDES, COMFORT ASSESSMENT, WEARING COMFORT,

(Copy on file)

Abstract:
From the examples presented in this paper it is clear that many of the methods for applying psychological scaling to comfort problems are fairly well-established. The work further suggests that many aspects of comfort may not be resolvable as simple physical measurements of heat or moisture exchange or physical contact of clothing fabrics with the skin. This does not mean, however, that useful comparisons cannot be made or that the results will not be convincing on a sound statistical basis appropriate to each scaling technique used. Experience has shown that the most meaningful psychological scale work has resulted from studies in which the observer is permitted free use of the language he considers appropriate to describe the phenomenon under study. This article has many different ways to measure subjectively comfort. Also, many equations for statistical measurement.

Hollies, N.R.S. et al (1979). A human perception analysis approach to clothing comfort. *Textile Research Journal*, 49, 557-564.

Keywords: 21,47,9,17,10,1,
GARMENT DESIGN, WEARING COMFORT, COMFORT ASSESSMENT, FIREFIGHTERS' PROTECTIVE CLOTHING, COTTON, ARAMID (NOMEX, KEVLAR),

(Copy on file)

Abstract:
"Clothing comfort assessment by human perception analysis provides a sound basis for comparison of apparel garments under combined microclimates and human activity levels." (557)

Comparison of firemen's shirts: in-the-field survey of comfort and effectiveness; often garments worn under turnout coats are flammable and can cause severe burns; sweating combined with overheating and chilling also experienced.

Tested FR 100% cotton, 100% Nomex III, 100% crease resistant cotton for control

Shirts initially laundered 3 times and laundered after being worn.

Participants used descriptors (eg. sticky) in describing sensations - the greatest lowering of comfort was when temperature and humidity were high.

From the average data the shirts were rated first, second, third before and after exercise except for 'stiff' the two cotton shirts were first or second and there was no significant change in ranking due to exercise.

For most descriptors the cotton shirts were preferred over the Nomex shirt at the 99% confidence level. Nomex and FR cotton judged equally rough. Nomex and CR cotton judged equally nonabsorbent.

Jeans were also tested.

Holme, I. (1981). Fabrics and finishes for workwear. *Textile Institute and Industry*, 8, 231.

Keywords: 13,20,21,12,18,
F R WOOL (ZIRPRO), FOUNDRY WORKERS' PROTECTIVE CLOTHING, GARMENT DESIGN, F R FINISHES, FLAMMABILITY,

(NO Copy on file)

Abstract:
Summarizes four papers presented at Bradford, England on May 14th. Development of Zirpro flame-retardant for wool led to an increase in the use of wool fabrics for specialized markets for protective clothing, e.g., for racing drivers' uniforms and workers with coke ovens, blast furnaces and foundries. DuPont representative discussed developments in functional work-wear identity wear and disposable workwear. Also described in detail was the application of polymers from a liquid phase to woven, nonwoven and knitted fabrics. The more common coating methods and advantages and limitations were discussed, including problems in the use of synthetic fibers. Another lecturer commented on the influence on the workwear market by small rental companies, employers, and retail outlets. No overall growth in the market last year was attributed to the general industrial recession.

Holme, I. (1984). Flammability: continuing the battle. *Textile Horizons*, 4(4), 30 - 31.

Keywords: 43,18,47,29,21,40,37,15,13,12,10,30,
THERMAL PROTECTION, FLAMMABILITY, WEARING COMFORT, MILITARY PROTECTIVE CLOTHING, GARMENT DESIGN, TESTING AND TEST METHODS, REGULATIONS AND STANDARDS, FABRIC IGNITION TIME, F R WOOL (ZIRPRO), F R FINISHES, COTTON, MISCELLANEOUS F R FIBERS,

(Copy on file)

Abstract:
A Textile Institute Finishing Group conference included discussions on: the importance of comfort in flame-resistant finishing of military garments; the flame-resistance of textiles in relation to how this could affect the clothing requirements of servicemen; testing and the law; the role of textiles in the ignitability of upholstery composites; Zirpro wool textiles; the Proban 210 durable flame-retardant finish for cellulosic fibres and the range of Amgard flame-retardants used in interior design; the Fireword range of flame-retardant products; new developments in urethane foams; the use of Caliban F/RB flame-retardants; and Flovan (non-durable) and Pyrovatex CP(durable) flame-retardants.

Holmer, I. & Elnas, S. (1981). Physiological evaluation of the resistance to evaporative heat transfer by clothing. *Ergonomics*, 24(1), 63 - 74.

Keywords: 40,41,23,45,47
TESTING AND TEST METHODS, THERMAL / HEAT STRESS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), VAPOUR BARRIERS,
WEARING COMFORT,

(Copy on file)

Abstract:
A new method has been developed to determine the "effective" evaporative resistance of clothing in vivo. It is based on direct measurements of the water vapour pressure gradient between skin and ambient air and of the steady state rate of evaporative heat loss. Air is sampled by a system of tubes terminating at six different loci on the skin surface underneath clothing and pumped to an oxygen analyser via a mixing chamber. Water vapour pressure is derived from measurements of oxygen partial pressure in the atmospheric air using the general gas law. Evaporative heat loss is obtained from continuous weighing of the subject on an electronic balance, after correction for respiratory heat loss and metabolic weight loss. The technique was used to evaluate the heat transfer properties of two types of rainwear and an overall. A rainwear made of a new fabric (Gore-Tex) produced a significantly lower evaporative resistance than a rainwear made of traditional material (nylon). It is concluded that the present method, in combination with partitional calorimetry enables a direct and simultaneous determination of the resistances of clothing to dry and humid heat loss for both resting and working subjects.

The paper describes a new technique for the determination of water vapour pressure at the skin surface and its application to measurements of dry and evaporative heat transfer through clothing. A heat balance method was employed for estimation of the sensible and evaporative heat losses of resting and working subjects.

Holmes, F.H. (1977). Flammability testing of textiles. *Textiles*, 6(1), 17 - 20.

Keywords: 40,18,37,15,
TESTING AND TEST METHODS, FLAMMABILITY, REGULATIONS AND STANDARDS,
FABRIC IGNITION TIME,

(Copy on file)

Abstract:
- Has on what to measure
- p. 19 of the article has a picture of whole garment burn testing.
- discusses various test methods on burning and if the methods are realistic to real life situations
- lists many standards on flammability

Hom, S. (1980). Breathing apparatus and firefighter deaths - part 1. *Fire Command*, 47(6), 24.

Keywords: 5
BREATHING APPARATUS,

(Copy on file)

Abstract:

Hom, S. (1980). Breathing apparatus and firefighter deaths - part 2. *Fire Command*, 47(7), 22.

Keywords: 5
BREATHING APPARATUS,

(Copy on file)

Abstract:

Hoschke, B.N. (1973). Flame-resistant pure wool for racing drivers. *Textile Journal of Australia*, 48(4), 20 - 23.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Hoschke, B.N. (1974). Flame-Resistant wool/Nomex blends. *Textile Research Journal*, 44(12), 956 - 958.

Keywords: 1,13,4,12,35,11,37
ARAMID (NOMEX, KEVLAR), F R WOOL (ZIRPRO), BLENDS, F R FINISHES, PHYSICAL PROPERTIES OF F R FIBERS, DURABILITY OF F R FIBERS, REGULATIONS AND STANDARDS,

(NO Copy on file)

Abstract:
Results of experiments on a lightweight fabric consisting of 80% wool and 20% polyester (or 20% Nomex) indicate that when the wool portion is treated - for example, with potassium zirconate - the amount of flame-resistant, synthetic fiber can be reduced, yielding a product of appropriate fabric strength, while still meeting U.S. Federal Aviation Administration requirements.

Hoschke, B.N. (1981). Standards and specifications for firefighters' clothing. *Fire Safety Journal*, 4, 125.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Hoyle, C. (1979). Nomex aramid fiber. *Canadian Textile Journal*, 96, 50 - 51.

Keywords: 43,1,23,18,47,11,16,35,42
THERMAL PROTECTION, ARAMID (NOMEX, KEVLAR), HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, WEARING COMFORT, DURABILITY OF F R FIBERS, FABRIC SYSTEMS, PHYSICAL PROPERTIES OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES,

(NO Copy on file)

Abstract:
Nomex
- outstanding high temperature properties; inherently flame resistant, outstanding protection with good economics and ease of care
- does not melt or drip - no significant afterglow - no offensive odors
- low thermal conductance - Nomex Plus fabrics made from it
- comfortable, pleasing to touch, resist soiling, launder clean and dry quickly, dimensionally stable, can be pressed or ironed
- durable as very tough, abrasion resistance is excellent, high tear strength, good chemical resistance
- two layers give more protection than the same single thickness

Huck, J. & McCullough, E.A. (1985). Insulation characteristics of outdoor garments and fabric systems. *Home Economics Research Journal*, 13(3), 324 - 333.

Keywords: 24,47,21,8,16,14,27,40
INSULATIVE PROPERTIES, WEARING COMFORT, GARMENT DESIGN, CLOTHING SYSTEMS, FABRIC SYSTEMS, FABRIC CONSTRUCTION, MANNEQUINS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
The thermal insulation (clo) values of different combinations of shell fabrics, linings and filling materials were measured using a guarded hot plate. The same fabric systems were constructed into long and short coats, and an electrically heated manikin was used to measure the insulation provided by each coat worn with a standard set of indoor garments. The type of fabric and/or filling material significantly affected the insulation provided by fabric systems and coat ensembles. The long coats were significantly warmer than their shorter counterparts and the sensitivity of garment clo to fabric clo was greater for the long coats than for the short coats. It appears that small differences in the thermal insulation of fabric systems become more important when most of the body is covered with a given fabric system. However, when an outdoor garment covers only part of the body and is worn over garments with less thermal resistance, the garments' contribution to total body insulation is lessened.

Huckeba, J.A. & Pierson, R. (1972). Report of tests on firefighters turnout coats. National Bureau of Standards.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Hughes, J.C. (1972). Personal protective equipment for hot work. *Proceedings of the New South Wales Industrial Safety Convention*, Sydney Australia.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Hunter, R.S. (1975). The measurement of appearance. John Wiley and Sons, New York, 348 pps.

Keywords:

(Copy NEVER VIEWED)

Abstract:

First part of book - concerns itself with the nature of appearance using an interdisciplinary approach involving physics, physiology, psychology, psychophysics and materials technology.

Part 2 - deals with the development of numerical specifications for appearance attributes using psychophysics.

Part 3 - describes instruments for the measurement of appearance, and final chapter discusses specific applications of appearance measurement.

Hunter, R.S. (1975). *The measurement of appearance.*. New York: John Wiley & Sons.

Keywords: 9,47
COMFORT ASSESSMENT, WEARING COMFORT,

(NO Copy on file)

Abstract:

The appearance of an object involves not only color, but also attributes such as gloss, luster, and translucency. This book has been written to discuss these appearance attributes of objects and the methods for their measurement. The first part of the book concerns itself with the nature of appearance using an interdisciplinary approach involving physics, physiology, psychology, psychophysics, and materials technology. The second part of the book deals with the development of numerical specifications for appearance attributes using psychophysics-i.e. the use of physical techniques to measure aspects of psychological significance. The thire part describes instruments for the measurement of appearance, and a final chapter discusses specific applications of appearance measurement. The book is well-sritten and illustrated and can serve as a textbook as well as a reference work.

Iampietro, P.F. & Goldman, R.F. (1965). Tolerance of men working in hot humid environments. *Journal of Applied Physiology*, 20, 73 - 76.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Ingham, P.E. (1978). Evaluation of wool protective clothing. *WRONZ Report 55.* Christchurch: Wool Research Organization of New Zealand.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Isaacs, J.L.. (1970). The oxygen index flammability test.. *Journal of Fire and Flammability*, 1(1), 36-47.

Keywords: 18,40,
FLAMMABILITY, TESTING AND TEST METHODS,

(NO Copy on file)

Abstract:

Jackson, R.H. (1978). PBI fiber and fabric - properties and performance. *Textile Research Journal*, 48, 314 - 319.

Keywords: 43,33,18,23,11,47,35,42,
THERMAL PROTECTION, PBI, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
DURABILITY OF F R FIBERS, WEARING COMFORT,
PHYSICAL PROPERTIES OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES,

(NO Copy on file)

Abstract:

Flame Resistance - LOI = 38%, COC = 28%, PBI will not burn in air - if exposed to high temperature or high heat flux for a long period of time, PBI will eventually char but the fabric retains its integrity and pliability (allows protection and freedom of movement)

Smoke Generation - PBI generates little or no smoke when exposed to flame or heat

Offgases - up to 560C, the PBI offgases are not toxic. Only above the onset of rapid degradation (at about 560C) are trace quantities of toxic gases released

Thermal Stability - excellent

Dimensional Stability - untreated, good - acid treated PBI, no shrinkage between room temperature and 450C. PBI (treated and untreated) has minimal shrinkage at temperatures well above the operating limits of other high temp. fibers. Important as shrinkage restricts movement and may eventually lead to rupture of the fabric and/or seams, exposing the wearer to the hazard.

Textile Properties - about the same as conventional polyester staple

Comfort - at 65% RH and 21C, moisture regain greater than 13% (similar to cotton), aramid 5%

Abrasion Resistance - very good - PBI and aramid both lose strength with abrasion but PBI loses less strength and at a slower rate.

Dyeability - naturally gold shade - can be dyed to almost any medium or dark shade - color will darken on sufficient exposure to UV light - fair lightfastness

Jaynes, P.S. (1980). Testing fabrics with molten steel. *Professional Safety*, 15 - 20.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Johnson, D. (1959). Candidate materials for high temperature fabrics. *Wright Air Development Center technical Report 59-155.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Johnson, D.H. & Beck, K. (1975). Protecting firemen on the fireground. *Fire Engineers Journal*, 35(100), 34 - 39.

Keywords: 43,17,18,21
THERMAL PROTECTION, FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, GARMENT DESIGN,

(NO Copy on file)

Abstract:
Problems associated with the preplanning for safety and the design of protective clothing and equipment are discussed. See: Beck, K. "Part 2: Clothing and Equipment".

Johnson, W. (1972). *Impact strength of materials.* NewYork: Crane Russak.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Johnston, R. and Radnofsky, M.I. (1968). Nonflammable clothing development program.. *Fire Technology*, May, 1968, National Fire Protection Association, 88-102.

Keywords:

(Copy on file)

Abstract:
Protective clothing is of major importance in our space program. The authors discuss the requirements, selection, and testing of materials considered for use in the program. The various types of garments worn by astronaut and support personnel are briefly described.

Kalekar, A.S. & Kung, H.C. (1972). Pre-Ignition heat transfer in fabric-Skin systems: dry fabrics. *Textile Chemist and Colorist*, 4(8), 29.

Keywords: 6,23,41,47
BURN INJURY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL / HEAT STRESS, WEARING COMFORT,

(Copy on file)

Abstract:
This paper is concerned with the theory of pre-ignition temperature-time history in a system consisting of a dry fabric, air gap and human skin which has been subjected to a radiant heat source. The system resembles the case of a person wearing a single garment. The fabric is subjected to a heat source and the time taken to ignite the fabric, as well as for the skin to feel pain, are calculated along with detailed temperature profiles. Numerical solutions are obtained for this mathematical model and limited comparison made with some simple experiments.

Kamin, J.I., Coletta, G.C. (1976). A research study for the development of criteria for fire fighters' gloves. *Conference on Protection for Fire Fighters*, ITT Research Institute, Chicago.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Kamon, E., Avellini, B. & Krojewski, J. (1978). Physiological and biophysical limits to work in the heat for clothed men and women. *Journal of Applied Physiology: Respiration, Environment and Exercise Physiology*, 44(6), 918 - 925.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Karter, M.J. (1980). Firefighter injuries in the U.S. during 1979. *Fire Command*, 47, 25 - 32.

Keywords: 17,41,18,23,6
FIREFIGHTERS' PROTECTIVE CLOTHING, THERMAL / HEAT STRESS, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), BURN INJURY,

(Copy on file)

Abstract:
Major cause of firefighter injuries was exposure to fire products, second leading cause was stress (including overexertion).

Causes of injuries: exposure to fire products (31.6%); exposure to flame (16.1%); exposure to smoke (9.4%); exposure to flame and smoke (6.1%); stress (20.2%); rubbed by, contact with object (12.9%); struck by object (0.4%); fell or stepped on (9.6%); structural collapse (9.0%); caught or trapped; exposure to chemicals or radiation; other.

Nature of Injuries: burns and smoke inhalation; burns only; smoke inhalation only (total 34.0%); strain, sprain (25%); wound, cut, bleeding (23.6%); dislocation, fracture; heart attack; shock; internal injury; not specified; other.

Selected Incidents:
- 13 firefighters caught by a blast received burns on the ears, face and wrists
- after knocking a fire down, firefighters removed SCBA masks and whil overhauling they were subjected to light smoke and fumes from PVC items.
- long hours and heavy smoke and heat conditions overcame 9 men
- plate glass door blew out, 1 man suffered a severely broken leg, flying glass sliced through another man's boot cutting nerves and tendons and causing muscle damage. Two men suffered cuts on wrists and hands and one firefighter was burned on the face.
- 94F ambient temperatures and hot fire conditions lead to 16 firefighters being treated for heat exhaustion - other injuries included smoke inhalation minor burns and particles in the eyes.

Kasem, M.A. & Roriette, H.K. (1972). Flammability and flame retardancy of fabrics: a review. *Journal of Fire and Flammability*, 3, 316 - 329.

Keywords: 43,18,14,42,35,11,15
THERMAL PROTECTION, FLAMMABILITY, FABRIC CONSTRUCTION, THERMAL PROPERTIES OF F R FIBRES, PHYSICAL PROPERTIES OF F R FIBERS, DURABILITY OF F R FIBERS, FABRIC IGNITION TIME,

(NO Copy on file)

Abstract:
Fabric characteristics such as construction, weight per unit area and surface smoothness affect flammability

Fabric flammability measured in terms of ignitability - measure of the ease with which a fabric enflames and combustability - related to rate of flame spread along a fabric specimen under a given test procedure - Untreated fabrics, AATCC-33-1962 measures rate of burning and ease of ignition to compare flammability of fabrics

Rate of flame travel, ignition temperature, flame temperature can also be used to evaluate flammability

For FR fabrics, flammability evaluated in terms of afterflame, char length and after glow - AATCC-34-1969 - vertical char test.

Oxygen index also measures flammability - affected by fabric weight, specimen size, enclosure chimney, horizontal and vertical mounting and direction of gas flow. OI decreases with increase in preignition temperature of the fabric.

66 ref.

Kaswell, E.R. (1972). Some thoughts and information on nonflammable products. *Journal of the American Association of Textile Chemists and Colorists*, 4, 33 - 40.

Keywords: 43,18,11,24,14,15,23
THERMAL PROTECTION, FLAMMABILITY, DURABILITY OF F R FIBERS, INSULATIVE PROPERTIES, FABRIC CONSTRUCTION, FABRIC IGNITION TIME, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(NO Copy on file)

Abstract:
Flammability is evaluated by ease of ignition, rate of burning, ease of extinguishment, types and amounts of smoke and toxic gas generation, thermal insulation ability and integrity of the material at and during the time of heat and fire exposure.

Flammability characteristics are functions of fiber properties and yarn and fabric structure.

Katzel, J. (1978). A guideline to selecting protective clothing.. *Plant Engineering*, 32(23), 82, 99, 104 & 105.

Keywords: 21
GARMENT DESIGN,

(NO Copy on file)

Abstract:

Katzel, J.. (1983). Some tips on selecting protective clothing.. *Plant Engineering*, 37(February), 26-28.

Keywords: 21
GARMENT DESIGN,

(NO Copy on file)

Abstract:

Kawabata, S., Postle, R., & Niwa, M. (1983). *Objective specification of fabric quality, mechanical properties and mechanical performance.* Osaka, Japan: TMSJ.

Keywords: 7,14,35,40,
CHEMICAL RESISTANCE, FABRIC CONSTRUCTION, PHYSICAL PROPERTIES OF F R FIBERS, TESTING AND TEST METHODS,

(NO Copy on file)

Abstract:
Ever since the first attempt was made to treat textiles as engineering materials, the problems of how to specify objectively the properties of fabrics, and how to relate measurable properties to functional performance in subsequent manufacturing, and to aesthetic appreciation, have been major ones. It is so mujch more difficult than measuring the resistivity or the modulus of a metal and recording a value in a table.

Pierce devoted a lot of effort to these problems, and, later, so did Hamburger. They tried hard to relate measurements to the needs of industry, but progress was limnited. Today, the leader in this attempt is professor kawabata. Over a period of years, he has systematically developed a range of test methods and, through his collaboration with mr. kato has made available on the market a set of well-designed and well-made instruments. At the same time, he has brought together panels from the industry to evalutate the subjective assessment of fabric handle, and, in a more questionable part of the work, ha developed statistical techniques to relate the subjective and objective information. Finally, and perhaps most important commercially, he has shown the clothing industry how they can use objective measurement to characterize fabric performance in making-up.

There are other things in this book, which is a record of a Japan-Australia joint symposium, but its main value is as the best starting point for a study of Kawabata's work. As such it should be required reading for all those working at the interface of textile technology and garment technology.

- John Hearle

Kenton, E. (1979). Protective clothing. I. arctic and tropical environments. a bibliography with abstracts.. Springfield, Va, USA: National Technical Information Service, US Department of Commerce, Report NTIS/PS-79/0436.

Keywords: 43,47,21,24,47,3,
THERMAL PROTECTION, WEARING COMFORT, GARMENT DESIGN, INSULATIVE PROPERTIES, WEARING COMFORT, BEHAVIOUR AND ATTITUDES,

(NO Copy on file)

Abstract:
Reports on clothing for environmental protection in extreme climates are cited, including reports on specially developed fabrics and textiles, insulating methods, physiological and psychological responses of users, mobility and dexterity of wearers, care of specialized clothing, and human factors involved. This updated bibliography which has 118 abstracts supersedes NTIS/PS-78/0371, NTIS/PS-77/0318 and NTIS/PS-76/0267.

Kenton, E. (1979). Protective clothing. II. fire and radiation environments. a bibliography with abstracts.. Springfield, Va, USA: National Technical Information Service, US Department of Commerce, Report NTIS/PS-79/0437.

Keywords: 43,18,21,40,17,23,12,41,
THERMAL PROTECTION, FLAMMABILITY, GARMENT DESIGN, TESTING AND TEST METHODS, FIREFIGHTERS' PROTECTIVE CLOTHING,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), F R FINISHES,
THERMAL / HEAT STRESS,

(NO Copy on file)

Abstract:
Reports and research on clothing and equipment for maximum protection while fighting fires and in radiation conditions are described. Treatment of fibres and textiles, design of clothing, testing for physiological tolerances, methods of decontamination after exposure, and equipment acceptability are included. This updated bibliography which has 103 abstracts supersedes NTIS/PS-78/0372, NTIS/PS-77/0319 and NTIS/PS-76/0268.

Kenton, E. (1979). Protective clothing, part 4. industrial environments. National Tehnical Information Service, U.S. Department of Commerce, Springfield, VA.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Kim, C.J. & Piromthamsiri, K. (1984). Sensory and physical hand properties of inherently flame-Retardant sleepwear fabrics. Journal Paper No. 284 of the Home Economics Research Institute, College of Home Economics, Iowa State University, Ames, Iowa.

Keywords: 47,18,39
WEARING COMFORT, FLAMMABILITY, SLEEPWEAR,

(Copy on file)

Abstract:
Inherently flame-retardant sleepwear fabrics for children were assessed by 38 judges for sensory hand qualities using the semantic differential and for hand preferences using the full forced-choice paired comparison. A 99 point certainty scale was used for both assessments. Physical hand properties were also measured instrumentally. Sensory hand responses differed more by fabric construction type than by fiber content, where as hand preferences differed more by fiber content than by fiber construction type. There were no clear relationships between sensory hand qualities and preferences, although smoothness, softness and gentleness of hand were associated with more favorable preferences. The word pairs that described physical properties directly (eg. flimsy/firm for stiffness) were highly correlated with physical measures.

Knox, F.S., Wachtel, T.L. & McCahan, G.R. (1979). Bioassay of thermal protection afforded by candidate flight suit fabrics. *Aviation, Space and Environmental Medicine*, 50, 1023 - 1030.

Keywords: 18,43,29,6,1,33,30,16,25,23,
FLAMMABILITY, THERMAL PROTECTION, MILITARY PROTECTIVE CLOTHING, BURN INJURY, ARAMID (NOMEX, KEVLAR), PBI, MISCELLANEOUS F R FIBERS, FABRIC SYSTEMS, JP-4 FUEL FIRES, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
The United States Aeromedical Research Laboratory (USAARL) porcine cutaneous bioassay technique was used to determine what mitigating effect four thermally protective flight suit fabrics would have on fire-induced skin damage. The fabrics were 4.8 oz. twill weave Nomex aramid, 4.5 oz. stabilized twill (HT4) and 4.8 oz. plain weave Nomex aramid (New Weave Nomex or NWN). Each fabric sample was assayed 20 times in each of four configurations: as a single layer in contact with the skin; as a single layer with a 6.35 mm (0.25 in.) air gap between fabric and skin; in conjunction with a cotton T-shirt with no air gaps; and, finally, in conjunction with a T-shirt with a 6.35 mm air gap between T-shirt and fabric. Bare skin was used as a control. A JP-4 fuel furnace was used as a thermal source and was adjusted to deliver a mean heat flux of 3.07 cal/cm2/s. The duration of exposure was 5 s. Four hundred burn sites were graded using clinical observation and microscopic techniques. Used as single layers, none of the fabrics demonstrated superiority in providing clinically significant protection. When used with a cotton T-shirt, protection was improved. Protection improved progressively for all fabrics and configurations when an air gap was inrtoduced. The experimental high-temperature polymer consistently demonstrated lower heat flux transmission in all configurations, but did not significantly reduce clinical burns.

Konz, S. & Duncan, J. (1971). Evaluation of two water cooled hoods. *ASHRAE Transactions*, 77(1), 232 - 238.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Konz, S. & Aurora, D. (1973). An evaluation of a dynamic cooling shirt. *ASHRAE Transactions*, 79(I), 52 - 61.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Konz, S., & Gupta, V.K.. (1969). Water cooled hood affects creative productivity.. *ASHRAE Journal*, 11(7), 40-43.

Keywords: 47,24,21,23
WEARING COMFORT, INSULATIVE PROPERTIES, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(NO Copy on file)

Abstract:

Krasny, J.F. & Fisher, A.L. (1973). Laboratory modelling of garment fires.
Textile Research Journal, 43, 272-283.

Keywords: 6,8,16,27,18,40,23,21,44,10,15
BURN INJURY, CLOTHING SYSTEMS, FABRIC SYSTEMS, MANNEQUINS, FLAMMABILITY, TESTING AND TEST METHODS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), GARMENT DESIGN, UNDERWEAR, COTTON, FABRIC IGNITION TIME,

(Copy on file)

Abstract:

In an attempt to model real-life burn accidents, garment assemblies were burned on adult-size mannequins and the temperature distribution over the mannequin surface determined. Anaesthetized, shaved rats were exposed in openings in the mannequins in the spatial arrangements encountered in real-life garment fires. The correlation between the depth of burn into the skin and the temperature observed on the mannequin surface near the exposed skin seemed fair. In other experiments, the interaction of burning fabrics and depth of burn was studied by means of simulated garments fitted to anaesthetized, shaved rats.

Garment geometry was found to affect the burn injury potential as much as fabric parameters. It is discussed in terms of initial fabric to skin, fabric to mannequin and outerwear-underwear distance (these distances often change during the fire due to heat shrinkage of thermoplastic fibers, turbulence, etc.); formation of chimney spaces between fabric layers and the mannequin surface; and firestops such as belts.

Other experiments covered the effect of combinations of various fabrics, such as dress-slip assemblies. Garments made of FR-treated cotton fabric and 100% thermoplastic fibers did not ignite in our experiments when used as single layers. When combined with polyester/cotton blends in outerwear-innerwear assemblies, these fabrics caused smaller areas of the mannequins to be raised to elevated temperatures than the blend fabrics alone. This effect was particularly marked for the FR treated cotton.

In our experiments, polyester/cotton blends seemed to have more potential for causing injury than comparable, 100% cotton fabrics. 100% thermoplastic fiber fabrics appeared to have low injury potential.

The effect of fabric weight on the area of the mannequin raised to elevated temperatures was not clear cut, though it was obvious that heavier fabrics caused more severe injury to exposed skin, and were more difficult to extinguish by beating out the flames, than light fabrics.

Krasny, J.F., Singleton, R.W. & Pettengill, J. (1982). Performance evaluation of fabrics used in fire fighters' turnout coats. *Fire Technology*, 18(4), 309 - 318.

Keywords: 17,18,45,21,23,11,14,35,40,43
FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, VAPOUR BARRIERS, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), DURABILITY OF F R FIBERS, FABRIC CONSTRUCTION, PHYSICAL PROPERTIES OF F R FIBERS, TESTING AND TEST METHODS, THERMAL PROTECTION,

(NO Copy on file)

Abstract:
The physical characteristics of 8 turnout coat fabrics (outer shell) were tested and some were tested for heat protection in combination with typical vapour barrier and inner liner materials.

Outer shell tested before and after 5 laundering and shrinkage, weight, construction and thickness were recorded.

Tensile strength, tear strength, abrasion resistance (3 methods), pilling propensity and heat protective characteristics (2 methods) were established.

Krasny, J.F. (1986). Apparel flammability: accident simulations and bench-Scale tests. *Textile Research Journal*, 287 - 303.

Keywords: 18,40,27,15,23,6,
FLAMMABILITY, TESTING AND TEST METHODS, MANNEQUINS, FABRIC IGNITION TIME, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), BURN INJURY,

(Copy on file)

Abstract:
Various apparel flammability characteristics of more than 60 fabrics were explored within the framework of the Cooperative Industry Program on General Apparel Flammability sponsored by the American Textile Manufacturers' Institute. Testing consisted of apparel fire simulations on a full size mannequin and a device simulating a moving leg, as well as laboratory measurements of ignition time, heat release, weight loss, and linear and area flame spread. This paper supplements earlier reports by participants in the program by providing a different analysis of the experimental results. Almost any test method used for these purposes satisfactorily identifies apparel fabrics with low burn injury potential. Differentiation according to injury potential among the other fabrics does not appear to be possible with any single test method, although the heat release test methods appear more promising than the others. Fabrics with short ignition times and high heat release rates and high burn injury hazard. In addition, a tendency to continue burning after contact with a surface (as when a burning garment touches the skin), which is found only in a few fabric types, can add to the burn injury hazard. A test method concept that incorporates these three factors is discussed. Five tables of data and nine diagrams provide excellent supporting information.

Kupferman, Z. (1977). Non-reflective, wettable, fibrous fabric assemblies for firefighters' clothing. Natick, Mass.: Navy Clothing and Textile Research Facility.

Keywords:

(Copy NEVER VIEWED)

Abstract:
The firefighters' garment developed at NCTRF is made from water-absorptive fibrous assemblies in combination with a vapour barrier fabric and an insulating lining. When wetted, the heat protection is equal to or greater than that of the highly reflective, aluminized material currently used in close proximity to JP-4 fuel fires.

Kwan-Nan, Y. (1976). Calorimetric study on the burning of double-layer fabrics. *Journal of Consumer Product Flammability*, 3, 218.

Keywords: 40,18,16,10,12,
TESTING AND TEST METHODS, FLAMMABILITY, FABRIC SYSTEMS, COTTON, F R FINISHES,

(Copy on file)

Abstract:
The burning behavior of cotton, polyester and flame-retardant treated cotton fabrics in double-layer structures were investigated with an isoperibol calorimeter. Specimens consisting of a two-layer combination of these fabrics in different configurations (top/bottom) were studied. The heat released during burning of each of the double-layer structures was measured and compared to that released from single layers of fabric. The effect of spacing between layers was also studied. The results indicated that the configuration has little effect on the burning of a cotton-cotton combination. However, cotton-polyester combinations are significantly affected by the configuration since the burning of the polyester in the cotton-polyester combination is strongly dependent on the amount of heat released from the cotton. Reduction of the data provides information regarding the combustion characteristics of the polyester fabric.

Laing, R.M. & Ingham, P.E. (1984). Patterning of objective and subjective responses to heat protective clothing systems - part 1 - objective measurements of comfort. *Clothing and Textiles Research Journal*, 3(1), 24 - 33.

Keywords: 43,21,47,41,9,40,10,13,
THERMAL PROTECTION, GARMENT DESIGN, WEARING COMFORT, THERMAL / HEAT STRESS, COMFORT ASSESSMENT, TESTING AND TEST METHODS, COTTON, F R WOOL (ZIRPRO),

(Copy on file)

Abstract:

Five overalls of differing fiber content commonly used for protective clothing were compared on the basis of objective physiological measurements (microclimate humidity, skin temperature) obtained during a controlled wear trial conducted on four male subjects.

Work conditions of high radiant heat were provided by electrical heaters.

The subject followed an exercise routine - a 2 kg dumbbell was held in both hands and swung back and forth at a constant speed - standing 600 mm from the heat source. Skin temperature monitored in 4 locations with thermocouples and humidity measured on side of left leg with Vaisala humidity probe.

Subjective evaluations made following first and second exercise periods - visual evaluation of garment fit and "general comfort" evaluation made prior to the exercise sequence.

Visual Assessment of Fit - subjective response to thermal and humidity sensations (pre-exercise)

Exercise 10 min. - Rest, seated, 5 min. - Evaluation Post Exercise 1

Exercise 10 min. - Rest, seated, 5 min. - Evaluation Post Exercise 2

Results:
Humidity - relatively small (~7%) change during first exercise period; 24% drop for milled wool during rest period - absorption by cloth continued after sweating ceased.; once exercise recommenced a rapid increase in humidity occurred reaching a stable state after 2 min. (wool); shen exercise stopped ~46% drop for milled wool and aramid; significant differences occurred among subjects and times but not among overalls - subject/time and overall/time interactions also significant

Differences Among Garments - Poly/Cotton Blend - skin temperature fluctuates more than under other fabrics. Neither arm nor leg further protected by additional layer of underclothing as trunk - the use of additional cloth layer seems to minimize differences among fabrics evidenced by skin temp.; 100% cotton - trunk area skin temp. fluctuated more than other fabrics; Milled Wool - least fluctuation of skin temp. - maximum temperature increase lowest at leg and trunk and second lowest at arm; Only differences among regions and time significant; differences among subjects and overalls not significant; Wool provided buffering effect against rapid skin temp. changes and thus may provide a greater comfort level.

Lando, S. (1977). Protective clothing for industrial use. U.S. Army Foreign Service and Technology Center, Report 78-11-15-120.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Langstaff, W.I. & Trent, L.C. (1980). The effect of polyester fiber content on the burn injury potential of polyester/Cotton blend fabrics. *Journal of Consumer Product Flammability*, 7, 26 - 39.

Keywords: 40,4,10,18,27,6,
TESTING AND TEST METHODS, BLENDS, COTTON, FLAMMABILITY, MANNEQUINS, BURN INJURY,

(Copy on file)

Abstract:
A flat plate sensor test and a thermally instrumented mannequin were used to measure burn injury potential of several fabrics. A partial description of the construction of the mannequin is given. It was concluded that bench tests such as the flat plate sensor have utility in determining the heat emitted during fabric burning. Such values can accurately predict the effect on mannequin burn injury potential when changes are made in fabric of a given weight and construction. However, the use of such heat emission values to predict burn injury potential without regard to fabric weight, construction, and other undefined factors may not always be valid.

Leary, R.H. (1983). Protective clothing. *Textile Asia*, (July), 48 - 50.

Keywords: 1,18,13,40,43,
ARAMID (NOMEX, KEVLAR), FLAMMABILITY, F R WOOL (ZIRPRO), TESTING AND TEST METHODS, THERMAL PROTECTION,

(Copy on file)

Abstract:
The natural flame-retardant properties of wool are discussed. Aramids, carbon fibers and other materials used in protective clothing are evaluated. Test procedures used to evaluate various materials are discussed.

Leung, E.Y. (1988). A literature review of thermal injury.. Department of Mechanical Engineering, University of Alberta., March, 1988.

Keywords:

(Copy on file)

Abstract:

The objectives of the present report are to understand thermal injury and to provide methods for evaluation of skin damage due to thermal exposures. This report reviews the literature of thermal injury for the period from the late 1940's to the 1970's. Examination of the literature into the 1980's found that the quantification of thermal injury is still based on earlier work. This report covers a mathematical and experimental analysis of heat transfer to the skin, the studies of thermal properties of the skin and its physiological reactions to burns. Methods to estimate skin damage incurred during a burn were also included.

Lind, A.R. (1963). A physiological criterion for setting thermal environmental limits for everyday work. *Journal of Applied Physiology*, 18, 51 - 56.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Linde, F.J.G. van de & Lotens, W.A. (1981). Restraint by clothing upon firefighters' performance. *Proceedings of the International Conference on Protective Clothing Systems*, Stockholm.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Locke, J.W. (1978). Performance standards and safety. *ASTM Standardization News*, 6(1), 23 - 24.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Lundblad, B. (1985). U.S. air force (Space division) protective clothing development program. *Proceedings of ACPTC Combined Central, Eastern and Western Regional Meetings*, 218.

Keywords: 43,29,47,16,45,
THERMAL PROTECTION, MILITARY PROTECTIVE CLOTHING, WEARING COMFORT, FABRIC SYSTEMS, VAPOUR BARRIERS,

(Copy on file)

Abstract:
Initiated a program to develop lightweight, breathable protective garments practical for extended use by personnel not directly involved in propellant handling.

Garments should provide short-term skin protection against high vapor concentrations resulting from spillage and long-term skin protection against chronic low level vapor concentrations.

A multi-layer composite structure consisting of a non-woven fabric support, a microporous membrane layer, a silicone rubber sealing layer, and an ultrathin permaselective surface coating.

Lyons, J.W. (1970). The chemistry and uses of fire retardants. New York: Wiley - Interscience.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Mach, D., Kampl, R. & Lejeune, H. (1984). Flame-Retardant viscose fibres for production of flame-Retardant blended fabrics. *Chemiefasern/Testilindustrie with English Translations*,(11), 797 - 803 and E109 - 111.

Keywords: 43,30,4,18,11,35,47,42,1,10,13,39,
THERMAL PROTECTION, MISCELLANEOUS F R FIBERS, BLENDS, FLAMMABILITY, DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS, WEARING COMFORT, THERMAL PROPERTIES OF F R FIBRES, ARAMID (NOMEX, KEVLAR), COTTON, F R WOOL (ZIRPRO), SLEEPWEAR,

(NO Copy on file)

Abstract:
The properties of flame-resistant viscose rayon fibres developed by Lenzing A.G. include good processability, problem-free dyeing, good wear comfort and lasting fire-retardancy. Examples of their use and performance in blends with synthetic fibres, aramid, wool and cotton are described. Applications of the blends include protective clothing, furnishing fabrics, bedlinens and children's nightwear. This paper was presented at the 23rd International Man-Made Fibres conference, Dorbirn, Austria, September 1984.

Martin, H., de V. & Goldman, R.F. (1972). Comparison of physical, biophysical and physiological methods of evaluating the thermal stress associated with wearing protective clothing. *Ergonomics*, 15(3), 337 - 342.

Keywords: 43,40,41,47,27,5,29,24,9,8,
THERMAL PROTECTION, TESTING AND TEST METHODS, THERMAL / HEAT STRESS, WEARING COMFORT, MANNEQUINS, BREATHING APPARATUS, MILITARY PROTECTIVE CLOTHING, INSULATIVE PROPERTIES, COMFORT ASSESSMENT, CLOTHING SYSTEMS,

(NO Copy on file)

Abstract:
Results from heated flat plate measurements of materials used in the standard U.S. combat uniform and in three different CW protective clothing ensembles (two U.S. and one U.K.) are compared to the insulation and evaporative heat transfer properties of the uniforms made from these materials as measured on a static heated copper manikin. The relative rank of these 4 uniforms, with and without M17 gas mask, with respect to heat stress imposed on soldiers working in a hot environment, and the body heat storage during a 3.5 mph treadmill march for 110 min. (50 min. march, 10 min. rest, etc.) in a climatic chamber at 35C, 50% RH with 33 mph wind were predicted from these static measurements. Physiological chamber trials were then conducted under the specified conditions with 8 volunteer subjects to evaluate the accuracy of the rank ordering and of the heat storage predictions. The results confirm the relative ranking with respect to heat stress of these uniform systems from the static measures. However, the actual measured mean values of heat storage were substantially below those predicted from the static copper manikin insulation and evaporative impedance measures.

Maudsley, W.M. (1985). Report on a survey of firefighter attitudes towards their current protective clothing. Unpublished Paper, Edmonton Fire Department, Edmonton, Alberta.

Keywords: 3,17,
BEHAVIOUR AND ATTITUDES, FIREFIGHTERS' PROTECTIVE CLOTHING,

(Copy on file)

Abstract:
Purpose: To obtain firefighter opinions on various factors which might influence the acceptability of protective clothing.

McCone, L.K. (1962). Symposium on high-temperature fibers: HT-1 high temperature resistant polyamide fibers and paper.. *Textile Research Journal*, 32(9), 762-767.

Keywords: 1,30,23,18
ARAMID (NOMEX, KEVLAR), MISCELLANEOUS F R FIBERS, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY,

(Copy on file)

Abstract:

McCormick, E. (1964). Human factors engineering. New York: McGraw Hill.

Keywords:

(Copy NEVER VIEWED)

Abstract:

McCrone, I. (1985). Kevlar for NZ navy gear. *Textile Horizons*, 5(Nov.), 10.

Keywords: 43,18,1,29,22,13
THERMAL PROTECTION, FLAMMABILITY, ARAMID (NOMEX, KEVLAR), MILITARY PROTECTIVE CLOTHING, GLOVES, F R WOOL (ZIRPRO),

(Copy on file)

Abstract:
Antiflash hoods and gloves made from Kevlar issued to New Zealand Navy frigate crew.

A trend back to natural fibers because of ship fires started by missiles - need better flame-retardant fabrics that don't melt and cause severe burns to wearer. (ie. wool)

McCullough, E.A. & Noel, C.J. (1979). Flammability characteristics of layered fabric assemblies. *Journal of Consumer Product Flammability*, 6, 119.

Keywords: 43,16,18,10,4,14,6,8
THERMAL PROTECTION, FABRIC SYSTEMS, FLAMMABILITY, COTTON, BLENDS, FABRIC CONSTRUCTION, BURN INJURY, CLOTHING SYSTEMS,

(Copy on file)

Abstract:
The flammability characteristics of layered fabric assemblies in different spatial separations were investigated and the results compared to the burning behavior exhibited by the single layer components. Mens' woven dress shirt fabrics and knit underwear fabrics of cotton, polyester, and cotton/polyester blends were tested as single and double layer assemblies at different spatial separations using a modification of the Mushroom Apparel Flammability Tester. The findings indicated the fiber content of the fabric layers, the number of layers and the amount of space between the layers influence the flammability characteristics. Consequently, a test method and criteria based on the testing of single fabric layers would be ineffective in predicting potential burn hazards associated with garment assemblies.

McKinnon, G.P. (Ed.) (1976). Fire protection handbook. Boston: National Fire Protection Association.

Keywords:

(Copy NEVER VIEWED)

Abstract:

McNall, P.E., Joax, J., Rohles, F.H., Nevins, R.G. & Springer, W. (1967). Thermal comfort (thermally neutral) conditions for three levels of activity. *ASHRAE Transactions*, 731, 1.3.1 - 1.3.14.

Keywords:

(Copy NEVER VIEWED)

Abstract:

McNall, P.E., Ryan, P.W., Rohles, F.HJ., Nevins, R.G. & Springer, W.E. (1968). Metabolic rates at four activity levels and their relationship to thermal comfort. *ASHRAE Transactions*, 74(Part I,2067), IV 3.1 - IV 3.14

Keywords:

(Copy NEVER VIEWED)

Abstract:

McQuade, A.J., Waldron, E.T. & Farquhar, B.S. (1959). Response of fibers to intense thermal radiation. *Annals New York Academy of Sciences*, 82, 762 - 773.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Mehta, P.N. & Willerton, K. (1977). Evaluation of clothing materials for protection against molten metal. *Textile Institute and Industry*, 15, 334 - 337.

Keywords: 23,31,38,24,43,13,10,30,1,32,2,18
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), MOLTEN METAL EXPOSURE, SKIN SIMULANT, INSULATIVE PROPERTIES, THERMAL PROTECTION, F R WOOL (ZIRPRO), COTTON, MISCELLANEOUS F R FIBERS, ARAMID (NOMEX, KEVLAR), NOVOLOID (KYNOL), ASBESTOS, FLAMMABILITY,

(NO Copy on file)

Abstract:
In metal industries, heat and molten metal splash are the principle hazards.

Several fabrics are tested for the protection they offer. Molten metal is splashed off a solid surface onto the sample, simulating conditions in a foundry.

The fabric was evaluated in terms of the amount of metal adhering to the surface of the fabric, the extent of charring on the back of the fabric and the degree of damage done to the PVC "skin" placed behind the test fabric.

Of the fabrics tested, wool provided better protection compared to cotton, modacrylic, aramid, novoloid and asbestos fiber fabrics. This is attributed to the unique metal-shedding property of the fiber, the high thermal insulation and the resistance to melting of wool fabrics.

Mehta, P.N. (1980). Engineered wool industrial protective clothing. *Textile Research Journal*, 50, 185 - 193.

Keywords: 23,14,16,24,28,18,31,7,13,11,35,42
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FABRIC CONSTRUCTION, FABRIC SYSTEMS, INSULATIVE PROPERTIES, METALLIZED FABRICS, FLAMMABILITY, MOLTEN METAL EXPOSURE, CHEMICAL RESISTANCE, F R WOOL (ZIRPRO), DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES,

(NO Copy on file)

Abstract:
Workers may be exposed to convective, conductive or radiant heat transfer - rate of transfer measured as heat flux - quantity of heat passing through a unit area every second. Mode of heat transfer determines means by which protection should be achieved, measured heat flux determines level of protection needed and, together with exposure they define the heat hazard.

Conductive: fabric thickness and density important as insulation depends on air trapped between layers. Fiber type important when temp. reached is above decomposition temp. for the fiber.

Radiative: aluminized fabrics - effectiveness depends on method of aluminization

Flame Hazards: highest protection offered when a thin, tightly constructed outer fabric was used in conjunction with a thick inner fabric.

Protective properties of wool attributed to the highly insulating voluminous char formed on burning.

Molten Metal: wool good protection as good metal shedding properties and high thermal insulation - fabric structure important - thick, heavy wool better than thin, worsted fabrics. By increasing tightness of construction the weight of the fabric can be reduced without lowering protection. Two layers of fabric are inferior to a single layer of the same weight thickness.

Static Electricity: wool good as fabrics do not exhibit high surface resistivity unless in very dry atmosphere. Wool fabrics incorporating stainless steel yarns developed to combat the problem.

Chemical Hazards: tightly constructed woolen felt fabrics offer good protection.

Mehta, P.N. & Norman, D.A. (1983). Development of a new fire services wool tunic. *Textile Research Journal*, 53(3), 153 - 159.

Keywords: 21,13,17,23,41,7,45,18,8,40,
GARMENT DESIGN, F R WOOL (ZIRPRO), FIREFIGHTERS' PROTECTIVE CLOTHING, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL / HEAT STRESS, CHEMICAL RESISTANCE, VAPOUR BARRIERS, FLAMMABILITY, CLOTHING SYSTEMS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Main hazards to firefighter are radiant and convective heat. Exposure level varies with the size of the fire and the square distance from it. (typical exposure - 0.5 - 16 kW/m**2 with a maximum sustained exposure of 300 sec at top).

Physiological stress: the bulky, heavy clothing required for protection against environment increases heat build-up in the body by insulating against heat loss by the body and the extra effort needed to carry the extra weight. To permit perspiration evaporation the garment should be vapour permeable and the design optimize the exchange of air between the body and the internal clothing layers.

Good water repellency of outer layers necessary to prevent localized cooling.

Firemen face exposure to heat, direct contact with flame and hot, falling debris and exposure to water and chemicals.

18 different clothing assemblies were analyzed - 3 had vapour barriers or were made from coated fabrics. Constructed either single-layer with a thick, heavy swollen fabric or multi-layer with tightly woven thin outerwear and a lightweight bulky fabric for heat insulation - total garment weights were similar.

Flame resistance - NFPA 1971 - vertical flame test - all outer fabric passed but most lining and insulation materials burned the full length of the specimen.

Radiant heat - (20kW/m**2) - gas fired radiant panel specified in British Standard 3791-Ap.D. Protection was shown to depend on fabric thickness - 3.5 mm - 25 sec. protection can be considered basic level for tunic.

Flame - ASTM Designation D13-77-4 - horizontal sample exposed to flame of Meker burner and heat passing through measured by a copper calorimeter mounted adjacent to rear surface.

Mihal, C.P. (1981). Effect of heat stress on physiological factors for industrial workers performing routine work and wearing impermeable vapour-barrier clothing. *American Industrial Hygiene Association Journal*, 42(2), 97 - 103.

Keywords:

(Copy NEVER VIEWED)

Abstract:
It was found that the implementation of engineering and administrative controls and use of a vortex-cooled air suit significantly reduced the stress of working with vapour-barrier clothing at high temperatures.

Miller, B., Goswami, B.C., & Turner, R. (1973). The concept and measurement of extinguishability as a flammability criterion.. *Textile Research Journal*, 43, 61-67.

Keywords: 1,4,6,10,18,37,40,
ARAMID (NOMEX, KEVLAR), BLENDS, BURN INJURY, COTTON, FLAMMABILITY, REGULATIONS AND STANDARDS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Burning experiments in enclosed spaces have shown that oxygen depletion leading to flame extinction occurs even in a relatively large volume of air, because convection is only partially effective in supplying air to a burning flame and removing products of combustion and pyrolysis. Quantitative evaluation of extinguishability through oxygen depletion determined under realistic burning conditions would, therefore, be a valuable indication of the hazard potential of a material. Accordingly, a method has been developoed for establishing a characteristic minimum-burning condition in terms of oxygen concentration which results in a more stringent criterion for the innate flammability of a material than the conventional oxygen index (O.I.) value. The TRI Flammability Analyzer is used to measure steady-state flame propagation rates at several oxygen concentrations high enough to support steady burning. Extrapolating the resultant linear burning rate-oxygen concentration relation to zero burning rate-yields an intrinsic (O.I.). With the analyzer, it is possible to determine intrinsic indices for the more common and vigorous upward directions of burning, and the upward indices obtained for a group of natural and synthetic fabrics, woven and knitted, are appreciably lower than the indices for the downward direction. Indeed, all fabrics studied, except Nomex, are found to be inherently capable of upward burning in air.

Miller, G. (1974). Proban fR finish. *Symposium on textile flammability, 2nd Proceedings, Paper and Discussion*, 74 - 87.

Keywords: 10,12,18
COTTON, F R FINISHES, FLAMMABILITY,

(NO Copy on file)

Abstract:
No new information; not relevant.

Miller, J. (1986). Fire resistant workwear. *Occupational Health and Safety*, 8(4), 5 - 7.

Keywords: 43,18,19,6,12,23,
THERMAL PROTECTION, FLAMMABILITY, FLASH FIRES, BURN INJURY, F R FINISHES, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
The necessity of fire resistant workwear and that the worker and employer realize this necessity. Most workers caught in work site fires or explosions suffer injuries resulting not so much from the initial flash, but from the combustion of the clothes they are wearing. Industrial fires and explosions most often involve deep burns to large areas of the body as a result of clothing catching fire. The job of fire resistant workwear is to allow the worker to survive beyond the period of the initial fire, not to provide a flash fire with the fuel it needs to continue burning.

2 basic groups of fire resistant workwear: 1) workwear made from fire resistant materials; 2) standard workwear made fire resistant by treatments with chemical substances.

Certain properties fire resistant workwear must contain: must protect the weare from exposure to heat or flame; must not act as a fuel; must be anti-static, so as not to create the spark which might wet off a fire or explosion.

Article also lists arguments for fire resistant workwear against myths and misunderstandings.

Mixter, G. & Pearse, H.E. (1953). Studies of flash burns: the protection afforded by 2, 4 and 6 layer fabric combinations. The University of Rochester, Rochester, N.Y.: Atomic Energy Project UR 261.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Mixter, G. (1954). Studies on flash burns. University of Rochester: Atomic Energy Report UR-354 10/27/54.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Molter, J. (1975). Advances in protective clothing. *Fire Engineering*, 128(11), 29 - 31.

Keywords: 43,17,8,16,45,18,23,21,24,14
THERMAL PROTECTION, FIREFIGHTERS' PROTECTIVE CLOTHING, CLOTHING SYSTEMS, FABRIC SYSTEMS, VAPOUR BARRIERS, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), GARMENT DESIGN, INSULATIVE PROPERTIES, FABRIC CONSTRUCTION,

(Copy on file)

Abstract:
Advances in the design of different types of garments that are available specifically for various hazard levels are outlined. The chart presents findings for a number of typical systems in use. These data indicate each turnout coat system's ability to isolate and insulate the wearer from a high thermal hazard. The importance of the combination of material, weight and thickness is demonstrated in the table.

Morales, V. & Konz, S. (1968). The physiological effect of a water-cooled hood in a heat stress environment. *ASHRAE Transactions*, 74(II), 236 - 249.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Molter, J.O. (1976). A fibre producer looks at firefighters' protective clothing. *Conference on Protection for Firefighters*, ITT Research Institute, Chicago.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Morin, C.J. et al. (1977). Comparison of the wearing comfort of crease resistant cotton, fR cotton with THPOH-NH3 and nomex III firemen's shirts. Final Report, Gillette Research Institute.

Keywords: 43,47,9,1,10,12,8,44,18,
THERMAL PROTECTION, WEARING COMFORT, COMFORT ASSESSMENT, ARAMID (NOMEX, KEVLAR), COTTON, F R FINISHES, CLOTHING SYSTEMS, UNDERWEAR, FLAMMABILITY,

(Copy on file)

Abstract:
Multi-layer clothing systems - hazard if underlayers are flammable

Underlayers must be comfortable as they are worn around the firestation all day.

Firemen's shirts tested - comfort rated after exercise (10 minutes at 10 - 15 m/h on stationary bicycles - environment 92F) after which the men proceeded to an environmentally controlled room in which conditions were changed between hot-dry, hot-humid, cold-dry, cold-humid. Some men were exercised by raising their hands from waist to head 20 times.

Differences were perceived in the hot-dry, hot-humid climates.

Result - cotton shirts were preferred over the Nomex shirt.

Comfort Comparison Procedure: Data collected by comment as 2 sets of subjective ratings (1 - 5) from each of 25 men, for each garment. Data analysed using several tests: summarized by rank placement of shirts by comment before and after exercise; a T-test which compared FR cotton to others; an analysis of variance to determine the significance of comfort rating differences between shirt types.

Moritz, A.R. & Henriques, F.C. Jr. (1947). Studies of thermal injury II: the relative importance of time and surface temperature in the causation of cutaneous burns. *American Journal of Pathology*, 23(5), 695 - 720.

Keywords: 6,
BURN INJURY,

(NO Copy on file)

Abstract:
The reciprocal relationships of surface temperature and duration of hyperthermia in the production of cutaneous injury have been investigated for pig and man. The data were derived from experiments in which the surface of the skin was brought immediately to, and maintained at, a constant hyperthermic level in such a manner that there was no external mechanical interference with the flow of blood through the skin.

Although there were certain quantitative differences in the reactions of human and porcine skin to excessive heat, there were no significant quantitative differences in their susceptibility to thermal injury in these circumstances.

Moritz, A.R. (1947). Studies of thermal injury III: the pathology and pathogenesis of cutaneous burns - an experimental study. *The American Journal of Pathology*, 23(6), 915 - 941.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Morris, G.J. (1953). Thermal properties of textile materials. *Journal of the Textile Institute*, 44, T449 - T476.

Keywords: 43,18,42,24,47,23,14,16,
THERMAL PROTECTION, FLAMMABILITY, THERMAL PROPERTIES OF F R FIBRES, INSULATIVE PROPERTIES, WEARING COMFORT,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FABRIC CONSTRUCTION, FABRIC SYSTEMS,

(NO Copy on file)

Abstract:

Thermal Insulation - depends on thickness and is relatively independent of fibre type

Factors contributing to thermal properties: thermal conductivity of the fibre substance and of air contained within the structure; specific heat of the fibre substance; thickness of the fabric; bulk density of the fabric; surface of the fabric as affected by type of fibre; construction of the fabric; finishing treatment of the fabric; area of contact between fabric and other surfaces; heat loss by conduction from skin to fabric; heat loss by convection from skin through fabric and from fabric surface; heat loss by radiation; heat loss by evaporation of water from skin or fabric; heat gain due to water absorption by fabric; external atmospheric conditions i.e. temperature, relative humidity and movement of surrounding air.

Measuring Thermal Insulation: 1) Cooling Method - a hot body is surrounded by a fabric whose outer surface is exposed to the air and the rate of cooling of the hot body determined; 2) Disc Method - the fabric is held between 2 metal plates at different temperatures and the rate of heat flow measured; 3) Constant Temperature Method - the fabric is wrapped around a hot body and the energy required to maintain the body at a constant temperature is found.

Conclusions: Thermal insulation is primarily due to still air in fabric and yarns. The fibre type is of little consequence; thermal transmissivity decreases with density; fabric thickness most important factor in thermal insulation of textiles; when 2 fabrics have equal thicknesses the one with lower density has greatest thermal insulation but there is a critical density (0.06 g/cc) below which convection effects become important and thermal insulation falls; thermal transmissivity increases with moisture content; thermal insulation increases with air gap between hot body and fabric. There is a maximum air gap, about 3 - 4 inch above which insulation falls off - attributed to increased convection effects; increased wind velocity reduces the thermal insulation compared with insulation in still air (least effect with closely woven fabric); thermal insulation greatly increased if garment covered with a fine, closely woven outer fabric; fabric structure indirectly affects thermal insulation by varying fabric thickness and density; efficiency of insulator during wear depends on resistance to compression and ability to recover from compression if high ability - still air retained and good insulator.

Morris, M.A., Prato, H.H., Chadwick, S.L. & Bernauer, E.M. (1985). Comfort of warm-Up suits during exercise as related to moisture transport properties of fabrics. *Home Economics Research Journal*, 14(1), 163 - 170.

Keywords: 47,41,46,9,24,40,
WEARING COMFORT, THERMAL / HEAT STRESS, WEAR STUDY METHODS, COMFORT ASSESSMENT, INSULATIVE PROPERTIES, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
To assess the relationship between comfort and moisture transport properties of warm-up suit fabrics, a wear study was designed in which physiological and subjective measurements were obtained from subjects wearing warm-up suits under controlled conditions of exercise and environment. During the wear study, the subjects were under moderate heat stress in the warm environment and under no heat stress in the cool environment. Three fabrics were used in the study. Two of the fabrics were similar in thickness and insulative value but differed in ability to absorb and transport moisture. The other fabric had moisture properties that were similar to one of the above fabrics, but it was thinner and had a lower insulative value. Under cool environmental conditions, the three fabrics provided similar levels of comfort. When the wearers were subjected to moderate heat stress, they were most comfortable when wearing either the thinnest fabric or the fabric which absorbed and transported the most moisture. Comparisons between the two fabrics with similar insulative values indicated that the undergarments contained less moisture and the wearers felt drier when wearing the suit which had better moisture transport properties. Laboratory measurements of liquid transport and drop absorption were the best predictors of subjective evaluations of wetness and differences in the amounts of moisture in the garments when worn under conditions of moderate heat stress.

Morse, H.L. et al. (1973). Analysis of thermal response of protective fabrics. Technical Report AFML-TR-73-17, to the Air Force Materials Laboratory from the Aerotherm Division Acurex Corp.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Mueller, Kim (1985). "The emperor's new clothes": the role of protective clothing in the prevention of hazardous materials exposures. *Proceedings of: ACPTC Combined Central, Eastern and Western Regional Meetings*, 236.

Keywords: 7,5,21,47,18,23,43,
CHEMICAL RESISTANCE, BREATHING APPARATUS, GARMENT DESIGN, WEARING COMFORT, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION,

(Copy on file)

Abstract:
The following criteria are provided to encourage the development of better suits and materials: impermeability to 100% chemical exposure, compatibility with respiratory system, compatibility with communication systems, all components of top quality, supporting integrity of entire design, comfort, decontamination should not degrade future performance, shelf life = ten years, no degradation with ultraviolet or ozone exposure, wearing time = two hours minimum, chemical resistant for twenty hours total (minimum), ambient temperature = -20 to 40 C, fire retardant, inexpensive, easy to fabricate.

Munson, D.M., & Sprague, C.H. (1974). A composite ensemble method for estimating thermal insulating values of clothing. *ASHRAE Transactions*, 80(I), 120 - 129.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Murray, N.K. (1982). User evaluation of functionally designed protective clothing for agricultural workers. *Dissertation Abstracts International*, 43, 2868B.

Keywords: 21,34,
GARMENT DESIGN, PESTICIDE PROTECTIVE CLOTHING,

(Copy on file)

Abstract:

Neilson, E.B. & Richards, H.R. (1969). Fabric flammability: a proposed method for measuring rate-of-Burn. *Textile Chemists and Colorists*, 1(June), 270 - 277.

Keywords: 18,40,15,14,12,
FLAMMABILITY, TESTING AND TEST METHODS, FABRIC IGNITION TIME, FABRIC CONSTRUCTION, F R FINISHES,

(NO Copy on file)

Abstract:
A comparison is made for the rate-of-burning of free-hanging specimens with that for flame-supported specimens. For the flame-supported specimens of unfinished fabrics, the coefficient of correlation for time-to-burn with fabric weight is 0.95. The effects, on rate-of-burning, of specimen-width, fabric density, fabric thickness, ration of air volume to fiber volume and some resin finishes have been investigated. An improved method for measuring the rate-of-burning of fabrics is suggested. For the unfinished fabrics tested, the ease-of-ignition has a close linear relationship with the fabric weight.

Neilson, G. (1981). Safety in a flash. *DuPont Magazine* (U.S. Edition), 75(4), 2 - 5.

Keywords: 43,19,1,10,4,12,27,18,23
THERMAL PROTECTION, FLASH FIRES, ARAMID (NOMEX, KEVLAR), COTTON, BLENDS, F R FINISHES, MANNEQUINS, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
The safety margin of Nomex III aramid fiber compared with a plain cotton fabric, a cotton/polyester blend and cotton fabric treated with ammonia-cured flame-retardant in protective clothing in flash fires is demonstrated by the use of a manikin. It was found that the best protection was provided by Nomex III aramid fiber.

Nemec, M.M. (1978). Hand and body injuries: prime targets in the war on accidents. *Occupational Hazards*, 40(3), 37 - 42.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Neskestad, G., Kaleckar, A.S. & Kung, H.C. (1971). Study of pre-ignition heat transfer through a fabric-Skin system subjected to a heat source. Norwood, Massachusessets: Factory Mutual Research Corp., COM 73 10959.

Keywords: 6,23,43,15,
BURN INJURY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, FABRIC IGNITION TIME,

(NO Copy on file)

Abstract:
Theoretical and experimental studies of pre-ignition events transpiring in fabric-skin systems upon exposure to a radiant heat source are reported. Particular emphasis is placed on determining relationships between time to ignition of the fabric and time to pain in the skin of the fabric wearer which allows assessment of probabilities of ignition. Several common fabrics are ranked in order of decreasing safety as the pain time increases relative to the ignition time and evasive action by the fabric wearer becomes less and less effective.

Nevins, R.G., Rohles, F.H., Springer, W., & Fererherm, A.M.. (1966). A temperature-humidity chart for thermal comfort of seated persons.. *ASHRAE Journal*, 8(4), 55-61.

Keywords: 47,49,
WEARING COMFORT, BODY TEMPERATURE MEASUREMENT,

(NO Copy on file)

Abstract:

Newburgh, L.H. (1949). *Physiology of heat regulation and the science of clothing.* Philadelphia: W.B. Saunders.

Keywords: 49
BODY TEMPERATURE MEASUREMENT,

(NO Copy on file)

Abstract:

Nishi, Y. & Gagge, A.P. (1970). Moisture permeation of clothing - a factor governing thermal equilibrium and comfort. *ASHRAE Transactions*, 76(7), 137 - 145.

Keywords: 47,9,41,
WEARING COMFORT, COMFORT ASSESSMENT, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
Summary:

1) A "permeation efficiency factor", fpcl, has been defined that describes the "cooling" efficiency of sweating on the skin surface for a clothed human body.

2) The factor, fpcl, has been derived theoretically in terms of the convective heat transfer coefficient, hc, and the thermal insulation of the clothing, Icl.

3) Sublimation of naphthalene has been used to simulate the process of diffusive mass flow of water vapor from a skin surface through clothing to the ambient environment.

4) Experimental data derived by naphthalene sublimation have validated the theoretically predicted values of fpcl for naphthalene. By comparing the physical properties of naphthalene and water vapor, the same experimental data may be used to validate theoretically predicted value of fpcl for water vapor.

5) For clothing normally worn for comfort the "permeation efficiency factor" may be predicted with reasonable accuracy from its clo value and from the ambient air movement present.

The purpose of the paper is to develop a practical relationship between the resistance of clothing to water vapor and its transfer from the sweating skin surface. The heat balance equation for clothed subjects under the condition where all evaporation occurs at the skin surface will be validated by applying the fundamental mass transfer phenomenon of naphthalene sublimation rather than by water evaporation.

Nishi, Y. (1973). Vapor permeation efficiency of clothing by naphthalene sublimation. *Arch. Aci. Physiol.*, 27, A163 - A169.

Keywords: 9,47,
COMFORT ASSESSMENT, WEARING COMFORT,

(NO Copy on file)

Abstract:

Nishi, Y., Gonzalez, R.R. & Gagge, A.P. (1975). Direct measurement of clothing heat transfer properties during sensible and insensible heat exchange with the environment. *ASHRAE Transactions*, 81, 183 - 199.

Keywords: 23,47,41,9,43,45,40
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), WEARING COMFORT, THERMAL / HEAT STRESS, COMFORT ASSESSMENT, THERMAL PROTECTION, VAPOUR BARRIERS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
A method has been presented for the direct measurement of the thermal efficiency of clothing, when worn by live subjects during rest and exercise. From previous direct or calculated observations of the combined heat transfer cofficient (h) and the convective heat transfer coefficient (hc), the effective transfer coefficients for both sensible (h') and insensible (h'e) heat transfer can be calculated. From the thermal efficiency factor (Fc1) derived from Tsk and Tc1 measurements, an effective value for Iclo can be determined and the vapor permeation efficiency (Fpc1) can be determined, and ultimately the probable combination of operative temperature and humidity necessary for prediction of zone comfort, the limits for evaporative regulation, and the zone in which some degree of regulatory failure can be expected. When compared to manikin measurements, the unique advantages of the present method for evaluating the physical effect of clothing insulation are: 1) Only simple direct temperature measurements are used; 2) Energy measurements are unnecessary; 3) Evaluations of insulation properties over regional areas are possible during any type activity; 4) With prior knowledge of the convective heat transfer coefficient, the complete evaluation of heat and mass transfer coefficients involved becomes a reality.

Nivin, C.C. & Babbitt, J.D. (1938). On the heat transmission of textile fabrics. *Journal of the Textile Institute*, 29, T161 - T172.

Keywords: 40,23,47,16,14,8
TESTING AND TEST METHODS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), WEARING COMFORT, FABRIC SYSTEMS, FABRIC CONSTRUCTION, CLOTHING SYSTEMS,

(Copy on file)

Abstract:
An apparatus is described which the authors used for measuring the heat transmission of textile fabrics. The heat transmission of some of the clothing worn by men indoors was investigated at various wind velocities and curves relating conductance as well as T.I.V. with wind velocity for various fabrics and combinations of fabrics are given. The effect of a quarter inch air space between the clothing and the skin was also investigated.

T.I.V. - thermal insulating value

Norton, M.J.T., Johnson, R.F., & Jordan, K.A. (1984). Assessment of flammability hazard and its relationship to price for women's nightgowns.. *Textile Research Journal*, 54, 748-760.

Keywords: 6,8,10,4,12,14,15,18,21,23,27,40,
BURN INJURY, CLOTHING SYSTEMS, COTTON, BLENDS, F R FINISHES, FABRIC CONSTRUCTION, FABRIC IGNITION TIME, FLAMMABILITY, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), MANNEQUINS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
The flammability hazard and its relationship to price were assessed for 27 styles of women's nightgowns, purchased retail. Through the industry has commonly indicated that higher prices must be paid for safer garments, it was hypothesized that this would not hold among garments for which no mandatory standard beyond CS 191-53 has been imposed. Hazard was measured as the percentage of body area sustaining second degree burn, predicted through burning the nightgowns on a thermally instrumented mannequin. in general, predicted hazard was highest for cotton gowns, followed by ones of polyester/cellulosic and acetate/nylon blends, and lastly by ones of 100% polyester or nylon. Graphical and statistical analysis indicated an ionverse but weak relationship between hazard and price, so the sonclusion was that little if any necessary relationship exists between flammability hazard and price for the women's nightgowns. An apparent reason was the strong association between hazard and fiber content, but no discernible between price and fiber content.

Norton, M.J.T., Kadolph, S.J., Hohnson, R.F., & Jordan, K.A. (1985). Design, construction, and use of Minnesota woman, a thermally instrumented mannequin.. *Textile Research Journal*, 55, 5-12.

Keywords: 6,18,27,40
BURN INJURY, FLAMMABILITY, MANNEQUINS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
An adult female thermally instrumented mannequin was designed and constructed for apparel flammability research at the University of Minnesota. Forty-four chromel-alumel thermocouples (0.13 mm diameter) were encased in Pyrex, with measuring junctions exposed, and installed to measure surface temperatures during garment burnings. The thermocouples were arranged primarily in vertical and horizontal alignments on the mannequin torso. The basic mannequin, a molded polyester-fiberglass commercial display model, was coated with a wet mixture of ground asbestos, plaster of Paris, and building cement. The thermal inertia of the coating and the of Pyrex are thought to be close to the thermal inertia of skin and should thus accept heat at a rate approximating that of skin. Surface temperatures were initially measured by potentiometric recorders and then fit to a polynomial function, which provided input surface temperatures for a classical solution of internal skin temperatures. Subsequently, temperatures were recorded by a data acquisition system with and integrating voltmeter and used to calculate temperatures at depths by the finite element method. The degree of injury was predicted from time-temperature relationships at skin layer boundaries according to criteria established by henriques and modified by Stoll and Greene. Injury extent was expressed as a percentage of body surface area.

anz, W. (1970). Operations in hot environments and their special conditions. and Steel Institute, London, 51 - 53.

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stract:

Ordinanz, W. (1970). Personal adaptation and protective measures. In *Work in Hot Environments and Protection Against Heat*, The Iron and Steel Institute, London.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Ordinanz, W. (1970). Work in hot environments and protection against heat. Iron and Steel Institute, London.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Panek, C. (1982). DuPont aramid fibers for thermal protective clothing. *Protective Clothing Papers Presented at Shirley Institute Conference*, S45, 47 - 54.

Keywords:

(Copy NEVER VIEWED)

Abstract:

The requirements of thermal protective clothing are discussed. The factors influencing the selection of materials for improving the effectiveness of garments are considered with emphasis on DuPont's Nomex and Kevlar fibers and test methods to determine the suitability of a fabric for its intended use or protective level are described. Technical data are tabulated and illustrated.

Peirce, F.T. & Rees, W.H. (1946). The transmission of heat through textile fabrics. *Journal of the Textile Institute*, 37, T181 - T204.

Keywords: 23,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:

Pepler, W.H. (1986). Is there a F.E.A.T. in your future?. *Fire command*, June 1986, 14-17.

Keywords:

(Copy on file)

Abstract:

This paper describes research on a fitness program proposed for fire i fighters. The voluntary physical agility test is called the Fire Encounters i Acceptance Test, (thus, F.E.A.T.). The test, developed by the Tuscon Fire i Department, Arizona, uses job-related tasks as exercises. Our purpose was to i determine if total, mandatory implementation would be feasible and if it would i benefit the fire fighters, the department and the town.

Perkins, R.M. (1979). Insulative values of single-Layer fabrics for thermal protective clothing. *Textile Research Journal*, 49, 202 - 212.

Keywords: 43,24,23,18,11,21,14,15,
THERMAL PROTECTION, INSULATIVE PROPERTIES,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY,
DURABILITY OF F R FIBERS, GARMENT DESIGN, FABRIC CONSTRUCTION,
FABRIC IGNITION TIME,

(Copy on file)

Abstract:

Insulative values of garments worn to protect against damaging exposure to heat must be enough to prevent the heat transferred through clothing from causing serious discomfort or burns. Since many workers are exposed to radiant heat but only occasionally come in contact with flames, the insulative quality as well as flame retardancy must be measured. The clothing should not ignite or should self-extinguish, should insulate against heat levels expected during normal use and emergency exposure and should remain intact until evacuation or rescue.

The insulative properties and thermal disintegration of a variety of single layer fabrics was studied. When thermal energy reaches a fabric some is reflected, some absorbed with 95% reaching and absorbed by the skin, which, depending on the rate at which the heat is delivered and the total heat received, may cause burns.

Fabrics ranged from light to heavyweight and were subjected to radiant heat from 0.84 - 1.68 W/cm**2 and an open flame at 8.4/cm**2d.

Time to second degree burn, total heat transferred after a fixed exposure period (2 min. for radiant, 20 - 30 s for convective) and fabric appearance were observed.

Radiant - 0.84 W/cm**2 - fabric weight and air permeability determine protection; heavier fabric - better insulation; open construction - more air and more heat pass through; chemical finish has no significant effect except possible additional weight; all fabrics retained integrity; total heat transferred was less when air space between sensor and fabric.

Radiant - 1.26 W/cm**2 - fiber composition effected insulative value; ie. polyester melted and holes developed; modacrylic shrank and became brittle; disintegration of polyester and modacrylic greater when exposed to heat without restraint from frame.

Radiant - 1.65 W/cm**2 - FR cotton and wool charred and weak - as long as char was intact protection was provided; FR cotton disintegrated slower if backcoating; wet FR cotton provided more protection than dry for at least 2 min. exposure when fabric not in contact with sensor.

Convective - 8.4 W/cm**2 - FR cotton charred but did not shrink; FR wool and aramid fibers charred with some shrinkage; when unrestrained, modacrylic shrank and formed a brittle ball while restrained it offered some protection.

Peterson, J.L. (1976). The flammable fireman. *Conference on Protection for Fire Fighters*, ITT Research Institute, Chicago.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Phillips, A.W., M.D. (1974). Behavioral problems in burn prevention.. Eighth Annual Meeting of Information Council on Fabric Flammability - Dec. 5, 1974.

Keywords:

(Copy on file)

Abstract:
This paper deals with how to effectively teach the principles of fire i safety. It discusses obstacles to teaching such as fear and loss of audience i interest as well as ways of getting the message across successfully. It will i help educators learn why attempts at educating others have, in the past, not i proved successful.

Phillips, A.M. (1985). Fire fighters' protective clothing. Interim Status Review.

Keywords: 17,18,37,41,45,46,21,40,43,
FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, REGULATIONS AND STANDARDS, THERMAL / HEAT STRESS, VAPOUR BARRIERS, WEAR STUDY METHODS, GARMENT DESIGN. TESTING AND TEST METHODS, THERMAL PROTECTION,

(Copy on file)

Abstract:
The task group found that major technical questions impeding the development of standards for the performance of protective clothing are related to the retention of metabolic heat and the role of the vapour barrier. The task group has begun work on details of a research project that would answer these questions.

Ontario - did a field trial of 18 sets of uniforms of average design and performance (off-the-shelf items)

3 day seminar, simulated entry and search exercises were performed in the training tower by firefighters wearing various designs of clothing.

Each man swallowed a "radio pill" which measured body core temperature during the exercises and transmitted the readings to an external receiver. Allowed temps. to be monitored continuously without impeding the activities of the user.

Average body core temp. rose noticeably above the norm after 10 to 15 mins. of exercise. During the following rest period - little reduction in temp. during periods of up to 20 mins. When activity was resumed, core temps. increased rapidly to levels significantly above the norm. Measurements of the perspiration taken up by clothing indicated that evaporation was restricted. The results suggested that clothing can impede dissipation of body heat.

Pleasance, H.D. (1975). Wool's protective safety applications. *Textile Journal of Australia*, 5(10), 20 - 21; 34 - 35.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Pleasance, H.D. (1984). Developing a wool protective coverall. Unpublished Paper, Australian Wool Corporation, 369 Royal Parade, Parkville VIC 3052, Australia.

Keywords: 13,43,
F R WOOL (ZIRPRO), THERMAL PROTECTION,

(Copy on file)

Abstract:

Plitt, K.F. & Utech, H.P. (1971). Flammability of turnout coats tested. *Fire Engineering*, (Nov.), 60.

Keywords: 43,17,18,21,40,8,
THERMAL PROTECTION, FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, GARMENT DESIGN, TESTING AND TEST METHODS, CLOTHING SYSTEMS,

(Copy on file)

Abstract:
Four turnout coats were tested for flame-resistance using the vertical burn test (Method 5903 of Federal Test Method Standard No.: 191) and the char length used as the principle criterion by which to evaluate the test results. Each coat consisted of three layers; outer shell, interlining and inner liner and, in each coat, two of the three layers burned the entire length of the specimen. The outer shell, the most likely to be exposed to an ignition source, burned the whole length of the specimen for three of the four coats.

Plitt, K.F. (1972). Fabric tests on firemen's coats. National Bureau of Standards Report 10489.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Quintere, J. (1974). Radiative characteristics of fire fighters' coat fabrics. *Fire Technology*, 10, 153 - 161.

Keywords: 43,23,18,47,41,17,28,
THERMAL PROTECTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, WEARING COMFORT, THERMAL / HEAT STRESS, FIREFIGHTERS' PROTECTIVE CLOTHING, METALLIZED FABRICS,

(Copy on file)

Abstract:
Protective clothing provides thermal protection and comfort during exposure to fire or during work in normal climatic environments.

The clothing must be capable of protecting the wearer from severe exposure to heat transfer from fires, must be ventilated to allow dissipation of metabolic heat, must be comfortable.

Article examines only radiative contribution to the external heat transfer to firefighters coats.

Radiative heating depends on radiation source and on reflectance of surface being struck.

Reflectance of fabric depends on fiber material, dye, fabric construction.

Tested a number of fabric samples for reflective qualities.

Results: 1) "For good thermal protection from fires, the coat samples examined showed that color had a small effect on reducing the radiative heating load on the coat, and that soiled or wet clothing would negate any colour effect entirely"; 2) "Only special aluminized fabric constructions or pigments offered a distinct improvement in reducing the radiative heat load on the coat"; 3) "For thermal comfort in sunlight, color has a strong effect on the solar heating load, and light colours, as expected, tend to be best."

The implications of the results of spectral reflectance measurements reported here are considered for thermal protection and comfort of clothing worn by firefighters.

Radnofsky, M.I. (1971). Protective clothing. *Proceedings of a Symposium on Occupational Health and Hazards for the Fire Service*, 75.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Ramanathan, N. L. (1964). A new weighting system for mean surface temperature of the human body.. *Journal of Applied Physiology*, 19(3), 531-533.

Keywords: 49
BODY TEMPERATURE MEASUREMENT,

(Copy on file)

Abstract:
On the basis of an analysis of the skin temperature data on three resting human subjects from 112 experiments, a simple weighting system for computing the mean skin temperature from observations on four areas of the body, namely, chest, arms, thighs, and legs, has been proposed. The proposed system of weighting yields mean skin temperature values identical with the elaborate Hardy-Dubois weighting formula. The value of the medial thigh temperature as an index of the mean skin temperature has also been investigated and discussed.

Ramirez, J.E., & Dwiggins, C.F. (1985). High temperature papers made of polybenzimidazole.. *Tappi Journal*, 68(12), 12-14.

Keywords: 33,18
PBI, FLAMMABILITY,

(NO Copy on file)

Abstract:

Ramsey, J.D. (1975). Heat stress standard - how do we face up to it?. *Professional Safety*, 20(4), 20 - 24.

Keywords: 41,37,23,43
THERMAL / HEAT STRESS, REGULATIONS AND STANDARDS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION,

(Copy on file)

Abstract:
The author discusses the subject pertaining to heat stress standard and the safety professional's role in compliance with the standard. Guidelines for protecting the worker where heat stress may be excessive are also explored.

Ramsey, J.D. & Ayorib, M.M. (1975). Occupational heat stress. *Industrial Engineering*, 7(9), 38 - 42.

Keywords: 41,47,9,21,23
THERMAL / HEAT STRESS, WEARING COMFORT, COMFORT ASSESSMENT, GARMENT DESIGN. HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(NO Copy on file)

Abstract:
The authors take a practical look at the nature and measurement of occupational heat, and present several suggestions for the proper design and control of work situations involving heat stress hazards.

Exposure to hot environments can affect a worker's health directly ranging from simple discomfort, or fatigue to permanent health impairment or death.

Heat can also have safety implications as the worker's health may be affected due to loss of perceptual motor skills, annoyance, disruption or interference with the tasks at hand.

There are two classic heat disorders, heat stroke and heat exhaustion.

Methods to prevent heat disorders: Acclimatization - physiological adaption that takes place when a person works repeatedly in a given temperature. It leads to increased comfort, better ability to work, less potential physiological strain. Acclimatization schedules could be set up for new employees or anyone away for a long time; Ventilation Methods - general cooling, spot cooling, evaporative cooling systems for the workplace ie. fans; Radiant heat shields; Personal protective devices - personal cooling helmets, dry-ice jackets, etc., protective clothing good against radiant heat if a reflective surface, gloves, arm and leg shields, aprons can reduce radiant and conductive heat; Work-rest schedules; Medical examinations

Ramsey, J.D. (1978). Abbreviated guidelines for heat stress exposure. *American Industrial Hygiene Association Journal*, 39(6), 491 - 495.

Keywords: 37,41,47,40,9,
REGULATIONS AND STANDARDS, THERMAL / HEAT STRESS, WEARING COMFORT, TESTING AND TEST METHODS, COMFORT ASSESSMENT,

(NO Copy on file)

Abstract:
A wide array of recommendations, rules and research have been aggregated into a simplified set of decision criteria for estimating threshold levels of heat stress. The WBGT (Threshold Wet Bulb Globe Temperature) is used as a basis with appropriate modification for metabolic heat generated during work, velocity of air movement, state of acclimatization, amount of clothing (e.g. shorts, jackets, coats, enclosed suits), age, obesity and sex. When WBGT levels for the person-task-environment combination are exceeded, initiation of appropriate engineering and work practices are indicated.

Ramsey, J.D. (1978). Heat stress standard: OSHA's advisory committee recommendations. *National Safety News*, (June), 89 - 95.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Ramsey, J.D. & Bashir, M.Y. (1980). Subjective estimates of physiological responses and perceptual-motor performance in the heat. *Applied Ergonomics*, 11(4), 194 - 198.

Keywords: 46,47,41,
WEAR STUDY METHODS, WEARING COMFORT, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
A total of 31 male and 15 female subjects were selected for the present investigation. The subjects were all in excellent health and ranged in age between 18 and 40 years for the male group and 18 to 24 years for the female group. Four levels of temperature were used: 74, 90, 100F Wet Bulb Globe Temperature (23.3, 32.2, 37.8 and 43.3C WGBT respectively). Four perceptual-motor tasks were selected for this study reaction time, pursuit tracking, hand-eye coordination, and mental multiplication. Results indicate that the subjective estimates of physiological responses to heat can be used as a good indicator of the actual changes occurring in physiological responses due to heat exposure. The subjects were more sensitive to changes occurring in body temp. than to changes occurring in the cardiovascular system. Under the extreme hot condition (110F (43.3C) WGBT) subjects underestimated the effect on their physiological responses. Perceptual-motor performance is poorly estimated by subjects during heat exposure.

Rees, W.H. (1941). The transmission of heat through textile fabrics. *Journal of the Textile Institute*, 32(Aug.), T149 - T166.

Keywords: 43,40,23,24,16,47
THERMAL PROTECTION, TESTING AND TEST METHODS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES,
FABRIC SYSTEMS, WEARING COMFORT,

(Copy on file)

Abstract:
An apparatus is described for the measurement of thermal transmission through textile fabrics under conditions which simulate those of service. It comprises a circular horizontal plate, surrounded by a guard-ring and heated to a temperature approximately equal to that of human skin. The guard-ring is heated to identically the same temperature, so that all heat flows normally to the plate. The rate of flow of heat through the plate is measured by the rate of supply of electrical energy required to maintain the plate at the constant temperature. The fabric is clamped between two brass frames mounted so that it may be supported at any desired distance from the hot plate or in contact with it. The apparatus may be modified so that measurements may be made with both a temperature and a moisture gradient through the fabric. Results are given of tests with a thermal gradient only. A further modification of the apparatus enables the absolute thermal conductivity of materials to be measured, and this has been done to for the purpose of checking the apparatus. Measurements of the conductivity of various fabrics have also been made. The rate of transmission of heat through different materials has been measured, and also the effect of ventilation and humidity upon this rate. Measurements have been made of the increased insulation afforded by successive layers of a material, and of the "cold feel" or "chilling effect" of fabrics when first brought in contact with a warm body.

Reeves, W.A. (1983). What next for fire-Resistant textiles?. *American Dyestuff Reporter*, 72(1), 16 - 17.

Keywords: 43,18,12,39,37,
THERMAL PROTECTION, FLAMMABILITY, F R FINISHES, SLEEPWEAR,
REGULATIONS AND STANDARDS,

(Copy on file)

Abstract:
A brief survey (21 references) of the situation in the United States of fire-resistant fabrics and fire-retardant treatments in relation to children's sleepwear standards and their effects on marketing is presented. Bedding, upholstery fabrics and work clothing are also mentioned. The significant role played by publicity accompanying the establishment of the standards in educating the American public and reducing the number of deaths from ignition of textiles is noted.

Reische, U. & Stransky, A. (1980). Assessment of ventilation characteristics of standard and prototype firefighter protective clothing. *Textile Research Journal*, 50(March), 193 - 201.

Keywords: 43,17,21,7,18,23,41,47,6,5,
THERMAL PROTECTION, FIREFIGHTERS' PROTECTIVE CLOTHING, GARMENT DESIGN, CHEMICAL RESISTANCE, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL / HEAT STRESS, WEARING COMFORT, BURN INJURY, BREATHING APPARATUS,

(NO Copy on file)

Abstract:
Protective clothing protects against toxic chemicals, traumatic injury, flames, hot gases, steam, heat radiation, however, a lack of ventilation, which causes the generation of humid conditions, increases temperatures by reducing the sweat evaporation near the skin.

New suit developed to enhance metabolic heat dissipation while providing equivalent protection against the fire environment.

Coat: collar opening larger than standard coat, ventilation spacers around neck in spoke-hub configuration - extend into shoulder and over collar.

Collar: back twice height of front to protect back of neck and head, front does not interfere with breathing apparatus

Sleeves: act as bellows - vent openings under arms - zippered - can be opened and closed easily.

Front: zipper covered by storm flap and by a velcro closure.

Back: ventilation spacers from top of shoulder to below - ending at base of shoulder blades. Lower back "bellow design" weighted with sand - intended to move, counter to body motion creating air movement in back - outseams have zippered vents.

Coverall: zipper vents and vertical spacers. Vents are located on inner and outer seams of pant legs.

One standard and two versions of the new gear were tested during treadmill exercise with an increasing grade.

Reische, U. & Stransky, A. (1980). Comparative assessment of goretex and neoprene vapour barriers in a firefighter turnout coat. *Textile Research Journal*, 50, 643 - 647.

Keywords: 43,18,17,45,47,41,21
THERMAL PROTECTION, FLAMMABILITY, FIREFIGHTERS' PROTECTIVE CLOTHING, VAPOUR BARRIERS, WEARING COMFORT, THERMAL / HEAT STRESS, GARMENT DESIGN,

(NO Copy on file)

Abstract:

Turnout Gear consists of a durable, FR outer shell, a vapour barrier and a thermal liner: outer shell - flame resistant, protection against heat radiation, resistance to water; inner liner - insulating medium against heat conduction; vapour barrier - protection from steam and harmful chemicals.

Protective clothing accumulates metabolic heat due to poor ventilation and limited water-vapour transport away from skin.

Tests conducted to compare GORETEX to Neoprene, standard vapour barrier. A standard coat of 7.2 oz Nomex III aramid was interchanged with a liner and Neoprene-coated Nomex, pyjama check liner (3.0 oz.) and 3.0 oz. Nomex/Goretex laminated pyjama check fabric. Wear test - 2 females, 1 male - ten fast-responding termister-type temperature sensors were located in sleeves, crest, back and back of legs to measure air-temperature conditions inside protective clothing. Subjects reached 90 % of maximum exertion on a treadmill exercise protocol. Each subject was tested 3 times with each barrier alternating one per day.

Results: for all subjects the turnout coat temperature increased with exercise lowest overall temperatures in chest area. Lower metabolic heat buildup with GORETEX vapour barrier.

Reische, U., Stransky, A., DeLorme, H.R. & Travis, R. (1982). Advanced prototype firefighter protective clothing heat dissipation characteristics. *Textile Research Journal*, 52, 66 - 73.

Keywords: 18,45,43,21,23,17,41,14,47
FLAMMABILITY, VAPOUR BARRIERS, THERMAL PROTECTION, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FIREFIGHTERS' PROTECTIVE CLOTHING, THERMAL / HEAT STRESS, FABRIC CONSTRUCTION, WEARING COMFORT,

(NO Copy on file)

Abstract:

Improvements in garment design, fabrication and an innovative use of fabrics is needed to increase heat dissipation and prevent the heat accumulation which presently occurs in firefighters protective garments and often leads to heat stress - more ventilation is needed.

New protective clothing was designed to solve the problem of heat build-up.

Coat: reaches only to waist and provides more air circulation as does larger collar opening. Ventilation openings and spacers in back and chest penetrate inner liner and vapor barrier but not outer shell. Worn open during regular work but closed while firefighting.

Collar: twice as high in back as in front to provide protection for neck and head. Front allows room for breathing apparatus.

Front Closure: snap buttons and velcro covered by storm flap.

Coverall or Pants: ventilation openings and vertical spacers. Bib to protect chest when coat open. Suspenders allow loose fit and air circulation. Fastened in front by snaps and velcro.

Tested three versions of new prototype plus 1 turnout gear (standard) for ventilation effectiveness.

Subjects exercised both arms and legs for 20 min. with increasing resistance and an average air speed of 3400 mm/s was maintained by 2 fans located in front of the bicycle ergometers. - temp. 22C; RH 40 - 60 %

Results: the design provided significant improvement in heat dissipation - Wool with GORETEX barrier was best but weight disadvantage; Short coat and openings improved ventilation for arms and back but not in chest and legs - looser fitting coverall bib and more openings in legs may help; Design and fabric selection may help reduce heat stress and improve firefighter performance, health and safety.

Reischl, U. Ph.D. (1979). Water fog stream heat radiation attenuation.. *Fire Technology,* Volume 15, 1979, 262-270.

Keywords:

(Copy on file)

Abstract:

Tests indicate that water fog streams are effective in attenuating radiant i heat. It is suggested that such fog patterns be used for fire fighter i protection and be considered a part of the fire fighter's environment when i specifications for protective clothing systems are developed.

Renbourn, E.T. (1971). Physiology and hygiene of materials and clothing. Warford Herts, England: Merrow.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Renbourn, E.T. & Rees, W.H. (1972). *Materials and clothing in health and disease.* London: H.K. Lewis.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Rhodes, P.L. & Graham, C.O.Jr. (1979). Evaluation of cotton/Kevlar blends. *Textile Research Journal*, 49(1), 28 - 33.

Keywords: 43,18,1,10,4,35,11,12,
THERMAL PROTECTION, FLAMMABILITY, ARAMID (NOMEX, KEVLAR), COTTON, BLENDS, PHYSICAL PROPERTIES OF F R FIBERS, DURABILITY OF F R FIBERS, F R FINISHES,

(NO Copy on file)

Abstract:
Tests were made of Kevlar fiber blends of 5, 10, 15 and 20% with cotton. The processing efficiency of cotton/Kevlar blends compared favorably with that of blends of cotton with 15, 25, 35 and 50 % of polyester or 15% nylon. Lower twists were required for yarns spun from the cotton/Kevlar blends for optimum strength and stronger fabrics were produced than with comparable cotton blends with polyester or nylon. Blending Kevlar with cotton did not significantly increase either elongation of DP fabric or abrasion resistance, but it substantially increases tensile and tearing strength. Cotton/Kevlar fabrics treated with THPOH-NH3 are more flame-resistant and are stronger than similarly treated all-cotton fabrics.

Richards, H.R. (1984). Thermal degradation of fabrics and yarns. *Journal of the Textile Institute*, 75(1), 28.

Keywords: 18,12,13,10,4,23,11,35,42,40,
FLAMMABILITY, F R FINISHES, F R WOOL (ZIRPRO), COTTON, BLENDS, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES, TESTING AND TEST METHODS,

(NO Copy on file)

Abstract:
This multi-university study reports on untreated and flame-retardant (FR) wool, untreated and FR cotton and untreated and FR cotton-polyester fiber, blended-fiber fabrics which were exposed to elevated temperatures for different times and the changes in dimensional stability, tear resistance, breaking strength and colour were determined. For tear resistance and breaking strength, polyester fiber fabrics were less affected by heat than the other fabrics tested. The polyester fiber fabrics also retained their white appearance after all heat treatments, whereas all the other fabrics changed colour appreciably. The dimensional stabilities for fabrics were all quite good, with nylon and polyester fiber fabrics shrinking more than the others. Tear resistance was reduced appreciably more than breaking strength for all fabrics, with FR fabrics losing more than the untreated fabrics. A suggestion is made calculating, from the Arrhenius equation, the useful life of a fabric at any elevated temperature.

Rigakis, K., Kerr, N., Crown, B. & Eggertson, B. (1985). Efficacy of selected laundry practices used by alberta farm families in removing pesticide residues from clothing. *Proceedings of ACPTC Western Region Annual Conference*, Napa, California.

Keywords: 34
PESTICIDE PROTECTIVE CLOTHING,

(Copy on file)

Abstract:

Rohles F.H. Jr., Konz, S.A., McCullough, E.A., and Milliken, G.A. (1981). A Scaling procedure for evaluating the comfort characteristics of protective clothing.. Proceedings of the 1983 International Conference on Protective Clothing SystemStockholm, Sweden, Aug, 23-27, 1981, 133-140.

Keywords:

(Copy on file)

Abstract:

The requirement of measuring a persons feeling or response towards the environment has necessitated the development of rating scales. Four different aspects of the environment were discovered; pleasantness, visual clarity, complexity-novelty and spaciousness. In this paper, this approach and another were combined to develop a scale for evaluating the subjective responses not only to the environment, but to the various features and constituents that the environment contains. It will describe the procedure for developing the scale in a study conducted to determine the effect of temperature and garments on the acceptability and comfort of various types of protective clothing and the subsequent analysis used in its interpretation.

Rohles, F.H. Jr.. (1965). A psychologist looks at air movement.. *ASHRAE Journal*, 7(7), 48-49.

Keywords: 49,47
BODY TEMPERATURE MEASUREMENT, WEARING COMFORT,

(NO Copy on file)

Abstract:

Rohles, F.H. Jr., & Nevins, R.G. (1968). Short duration adaption comfortable temperatures. *ASHRAE Transactions*, 74(2065, Part 1), RP-43, IV.1.1 - IV.1.4.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Rohles, F.H. (1969). Preference for the thermal environment by the elderly. *Human Factors*, 11(1), 37 - 41.

Keywords: 47,41,9,37
WEARING COMFORT, THERMAL / HEAT STRESS, COMFORT ASSESSMENT, REGULATIONS AND STANDARDS,

(NO Copy on file)

Abstract:
On the basis of the responses of 64 elderly subjects (mean age 75 years) to two questionnaires, temperatures from 32F to 110F were classified as cooler-than-comfortable, comfortable and warmer-than-comfortable. The distribution of comfortable temperatures agree with experimentally derived findings on college-age and middle-aged adults with the mean, median and modal values falling within the ASHRAE Thermal Comfort Standard 55-66. The results conflict with the criterion stated in the ASHRAE Handbook (1967) that persons over the age of 40 prefer a temperature of comfort of 1 ET higher than that desired by persons below this age.

Rohles, F.H. Jr. (1971). Psychological aspects of thermal comfort. *ASHRAE Journal*, 13(1), 86 - 90.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Rohles, F.H. Jr.. (1971). The ecosystem complex a new approach in specifying the man-environment relationship.. *Journal Environmental Systems*, 1(4), 321-328.

Keywords: 47,49
WEARING COMFORT, BODY TEMPERATURE MEASUREMENT,

(NO Copy on file)

Abstract:

Rohles, F.H.Jr. (1974). The modal comfort envelope and its use in current standards. *Human Factors*, 16(3), 314 - 322.

Keywords: 9,47,43,41,40,46,37,
COMFORT ASSESSMENT, WEARING COMFORT, THERMAL PROTECTION, THERMAL / HEAT STRESS, TESTING AND TEST METHODS, WEAR STUDY METHODS, REGULATIONS AND STANDARDS,

(NO Copy on file)

Abstract:
A detailed study of thermal comfort was conducted by exposing 1600 subjects in groups of 10 subjects each (5 men and 5 women), to 20 dry bulb temperatures at each of 8 relative humidities (160 tests). From this study, 15 temperature-humidity conditions were selected (ET: 75.9 - 79.7F) and identified as the Modal Comfort Envelope (MCE). Within this envelope 94% of the subjects were either slightly cool, comfortable or slightly warm; 3% were cool and 3% were warm; and none were hot or cold. To validate these findings, a new sample of 150 subjects was tested and the results of this test agree favorably with the original findings. The MCE was used in a clothing study and in an investigation of thermal comfort in the elderly; the results of these studies are discussed, together with suggestions for the use of the MCE, as a tool for examining the thermal sensation as a function of such non-thermal factors as lighting, subject density, sex and activity. A slightly modified version of the MCE is currently being used as a standard for thermal comfort by ASHRAE and this is examined together with ASHRAE Comfort Standard 55-66, the New ASHRAE Comfort Chart, and the new Effective Temperature Scale.

Rohles, F.H. (1974). The measurement and prediction of thermal comfort. *ASHRAE Transactions*, 80(2039, Part 2), RP-118, 98 - 114.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Rohles, F.H., Hayter, R.B. & Milliken, G. (1975). Effective temperature [ET] as a predictor of thermal comfort. *ASHRAE Transactions*, 81(2368,Part 2), RP-11, 148 - 156.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Ross, J.H.. (1962). High-temperature fiber research.. *Textile Research Journal*, 32(9), 768-777.

Keywords: 12,18,42
F R FINISHES, FLAMMABILITY, THERMAL PROPERTIES OF F R FIBRES,

(NO Copy on file)

Abstract:

Ross, J.H., Schulman, S. & Stanton, R.M. (1971). Poly(1,3,4)-Benzimidazole - a nonflammable fiber for personal protection systems. *Textile Research Journal*, 41(Feb.), 146 - 153.

Keywords: 33,18,35,42,11,29,40,46,
PBI, FLAMMABILITY, PHYSICAL PROPERTIES OF F R FIBERS,
THERMAL PROPERTIES OF F R FIBRES, DURABILITY OF F R FIBERS,
MILITARY PROTECTIVE CLOTHING, TESTING AND TEST METHODS, WEAR STUDY METHOD

(NO Copy on file)

Abstract:
Fibers formed from poly(1,3,4)benzimidazole (PBI) have been spun, using the cotton system, into yarns and woven into a series of plain and twill-weave fabrics. The high moisture regain (10 - 13%), good abrasion resistance and high degree of heat-blocking, in addition to nonflammability in air, has resulted in PBI being considered for Air Force personnel protection systems. Laboratory and field evaluation of PBI fabrics in protection system configurations compared to currently used fabrics demonstrated the superior nonflammability of PBI. Based on data obtained, extensive wear testing of flight coveralls is to be initiated.

Ross, J.H. & Stanton, R.M. (1973). Relationship of fabric flammability to fabric structure. *Applied Polymer Symposium*, (21), 109 - 119.

Keywords: 43,14,1,33,32,40,18,11,25,47,
THERMAL PROTECTION, FABRIC CONSTRUCTION, ARAMID (NOMEX, KEVLAR), PBI, NOVOLOID (KYNOL), TESTING AND TEST METHODS, FLAMMABILITY, DURABILITY OF F R FIBERS, JP-4 FUEL FIRES, WEARING COMFORT,

(NO Copy on file)

Abstract:

Tested Nomex, PBI (polybenzimidazole), Kynol.

Basic vertical flame test primary means of evaluation - Nomex - increased weight results in increased glow time and char length - PBI - char length decreases with increased weight - Kynol - the surface chars and continues to glow after removal of flame source even though char length remains negligible.

Knit PBI - glow times varied and char length decreased with increasing weight and thickness. Air permeability demonstrated that as weight increased, the structure became more dense and would provide greater resistance to heat penetration.

Nomex shrinks above 600F but treated Nomex doesn't shrink until a much higher temp. and then very little although treatment doesn't improve flame, glow time or char length.

PBI twill type weaves of increasing weight burned in 100% oxygen atmosphere as weight and thickness increase, burning rate decrease - twill pattern had little effect on burning rate.

When a skin simulant is placed behind sample and heat rise measured, the results depend on weight and thickness - PBI - temp. rise increases with decreasing thickness.

J.P. fuel fire - Nomex - no flame time in vertical test but does burn when flame mass is large enough - PBI - emerges fire intact.

Inherent nonflammability of basic polymer major factor in flammability - weight and thickness secondary.

Fabric structure, weight and thickness more important role when measuring thermal protective capability.

Ross, J.H. (1977). Thermal conductivity of fabrics as related to skin burn damage. *Journal of Applied Polymer Science: Applied Polymer Symposium 31*, 293 - 312.

Keywords: 18,23,11,16,14,47,1,32,33,30,35,42,43
FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), DURABILITY OF F R FIBERS, FABRIC SYSTEMS, FABRIC CONSTRUCTION, WEARING COMFORT, ARAMID (NOMEX, KEVLAR), NOVOLOID (KYNOL), PBI, MISCELLANEOUS F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION,

(Copy on file)

Abstract:

Fabrics for protective clothing should exhibit specific characteristics: Fabric Flammability - shouldn't burn in fire or burn once removed (secondary hazard) and the higher the ignition temperature, the better the protection offered. Melting - fibers shouldn't melt, sticks to skin and transmits heat or can cause underclothing to ignite or allow hole formation causing direct exposure of skin. Heat Transfer - must provide a barrier to heat transmission from flames but not become a source of heat by emitting heat from the back side of the fabric. Thermal Stability - shrinkage voids the wearer of the protective insulating air gap between fabric and skin. Fabric Optical Properties (reflectance, absorbence and transmittance) - multiple fabric layers, more air gaps improve thermal protection.

Practical Considerations: Comfort (hand, moisture absorption, air permeability, fiber and fabric surface characteristics, finishes, construction, stiffness) - Durability - Aesthetics

Evaluated Nomex, Durette, Fypro, Kynol, HT-4, PBI, stabilized PBI - differed in fabric construction, air permeability, bulk density. Fabric Mechanical Properties - properties of Nomex and PBI after being stabilized for thermal stability and reduced shrinkage evident especially after abrasion test. Moisture Regain - low for all fibers except PBI which is greater than cotton. Vertical Flame - all good.

Thermal Evaluation Techniques: 1) 4 quartz lamps plus Meker burner fueled by natural gas; 2) a JP-4 fuel burner; Results: 1) 3 sec. exposure at varied intensities - 1.9 cal./cm**2 (no lamps on) - stabilized PBI provided best heat blocking, HT-4 also performed superior to other fabrics, PBI good at low exposure but at 2.6 cal/cm**2 sec. it shrank, Nomex shrank at 1.9 cal/cm**2 sec., Kynol forms char on surface and has excellent dimensional stability, Durette - complete protection at 1.9, but shrank just short of contacting sensor at 2.6; 2) stabilized PBI and HT-4 best in lab and field tests, PBI next best while the rest deteriorated badly and allowed extensive damage to occur under suits.

Conclusions: 1) fiber thermal stability most important when designing thermally protective clothing - must not melt, burn or shrink - stabilized PBI and HT-4 best meet this criteria. 2) fabric weight must be sufficient to provide thermally protective barrier, woven stabilized PBI or HT-4 should be 4.5 oz./yd**2(min.) to protect for 3 sec. at 2.6 cal/cm**2 sec.

Sagar, A.J.G. (1986). Protection against flame and heat using man-Made fibers. *Textiles*, 15(1), 2.

Keywords: 43,1,12,30,32,33,18,23
THERMAL PROTECTION, ARAMID (NOMEX, KEVLAR), F R FINISHES, MISCELLANEOUS F R FIBERS, NOVOLOID (KYNOL), PBI, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
This article covers flame-retardant (fr) and heat-resistant (hr) synthetic and regenerated fiber materials suitable for use in protective clothing.

Sasser, B.J. (1979). Protective clothing for molten aluminum exposure. Reynolds Metals Co., Box 27003, Richmond, VA 23261. Or abstract in *Journal of metals* 31 Dec. '79, p.134.

Keywords: 43,18,31,23,6,11,40
THERMAL PROTECTION, FLAMMABILITY, MOLTEN METAL EXPOSURE, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), BURN INJURY, DURABILITY OF F R FIBERS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Workers handling, or in near proximity to, molten aluminum face the risk of burns when splashes occur. Contact with molten aluminum can produce burns of varying degree dependent on the amount of metal making contact and the type of clothing worn by the worker. Clothing designed to protect workers in the steel industry was found to be unsatisfactory for molten aluminum even though aluminum is handled at substantially lower temperatures.

The Aluminum Association and the Industrial Safety Equipment Association undertook a joint program, in 1977, to evaluate a number of clothing fabrics. A series of molten aluminum splash tests on nearly 100 fabrics were conducted. The tests were to determine: 1) the effects of the molten aluminum on the fabrics, 2) the tendency of the aluminum to adhere to the fabrics and 3) heat flux through the fabrics using calorimetric instrumentation. The test methods and results are discussed.

Scheurell, D.M., Spivak, S.M. & Hollies, N.R.S. (1985). Dynamic surface wetness of fabrics in relation to clothing comfort. *Textile Research Journal*, 55(7), 394 - 399.

Keywords: 47,9,40,
WEARING COMFORT, COMFORT ASSESSMENT, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Moisture from perspiration collects in and passes through clothing as worn, and the properties of clothing fabrics influence both the collection and passage of this moisture. The selection and measure of moisture properties that relate to comfort in wear has proved to be more difficult than first perceived. Dynamic surface wetness of fabrics has been found to correlate with skin contact comfort in wear for a variety of fabric types, suggesting that mobility of thin films of condensed moisture is an important element of wearing comfort. This paper discusses how dynamic surface wetness is measured and calibrated against color standards used in the measurement.

This paper summarizes how the use of cobaltous chloride color changes has helped to define the moisture and comfort properties of clothing fabrics.

Scholander, P.F. (1947). Analyzer for accurate estimation of respiratory gases in one-Half cubic centimeter sample. *Journal of Biology and Chemistry*, 167, 234 - 250.

Keywords: 40,5,
TESTING AND TEST METHODS, BREATHING APPARATUS,

(NO Copy on file)

Abstract:

Schoppee, M.M., Skelton, J., & Abbott, N.J. (1977). The transient thermochemical response of protective fabrics to radiant heat. *AFML-TR-77-72.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Schoppee, M.M., Welsford, J.M., & Abbott, N.J. (1983). Resistance of navy shipboard outerwear garments and fire-resistant fabrics to extreme heat. Navy Clothing and Textile Research Facility Technical Report 153.

Keywords:

(Copy NEVER VIEWED)

Abstract:
The heat protective capabilities of a variety of fabrics used in Navy shipboard outerwear garments were characterized in several ways. Investigations included measurements of exposure to bilateral radiant heat, radiant heat transfer and flame impingement heat transfer.

Schulman, S., & Stanton, R.M. (1970). Nonflammable PBI fabrics for prototype air force flight suits. *Air Force Materials Laboratory Report AFL-TR-70-178.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Sellar, D. (1985). High-Performance aramid fibres - saving lives daily. *Australasian Textiles*, 5(4), 21 - 23.

Keywords: 1,18,
ARAMID (NOMEX, KEVLAR), FLAMMABILITY,

(NO Copy on file)

Abstract:
The use and performance of Kevlar fibres in tyre and industrial cords and protective clothing are discussed.

Shalev, I. & Barker, R.L. (1983). Analysis of heat transfer characteristics of fabrics in an open flame exposure. *Textile Research Journal*, 53(8), 475 - 482.

Keywords: 23,18,28,43,41,1,33,30,12,14,16,47,40
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, METALLIZED FABRICS, THERMAL PROTECTION, THERMAL / HEAT STRESS, ARAMID (NOMEX, KEVLAR), PBI, MISCELLANEOUS F R FIBERS, F R FINISHES, FABRIC CONSTRUCTION, FABRIC SYSTEMS, WEARING COMFORT, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Fabrics were exposed horizontally above an open flame of 2 cal/cm**2 s. exposure. This heat flux level is the average intensity which would be experienced by a firefighter (ASTM D-13-77, equivalent to above)

Emphasis on single layer woven fabrics ranging from light to heavyweight.

All were flame-resistant and some were aluminized.

Heavier fabrics had a higher thermal performance rating (above 20 cal/cm**2) eg. silica, ceramic, asbestos, albeit a medium weight zirconium treated, napped wool (30.4 cal/cm)

FR cotton depended on the type of FR treatment.

Aluminization decreases the performance in open flame exposure.

On weight normalized basis, aramids, PBI, crosslinked phenolics do well.

Fabric weight, thickness, density and air permeability are not sole factors in TPP rating as fiber properties and finishes play decisive roles in heat transfer.

General trend of increasing TPP with fabric weight and thickness.

Increasing density inhibits convective transfer but may enhance conductive transfer (saw no trend).

Air permeability shows no correlation to TPP for an open flame.

Some measure of protection may be afforded by fabric thickness, density and construction, other factors are thermal conductivity and heat capacity of the fibers, the nature of the boundary formed at the fabric air interface at the imposed aerodynamic conditions, the extent of endothermic reactions occurring in the solid or vapour phase, combustion products formed and their thermal properties, and the fabric moisture content.

The results may not be extrapolated to other heat flux levels or exposure times.

Aluminization is detrimental to this kind of heat assault.

Halogen based FR finishes on cotton performed better than phosphonium-type treatments, even on a weight-normalized basis for the fabrics tested.

Blends often display the desirable properties of the pure components and provide good protection at improved comfort levels.

Experiments measured the transfer of heat through protective fabrics when the exposure is to a convective source (open flame). An instrumented calorimeter located on the opposite side of the fabric measured the heat transferred. Heat flux data were used to compute a burn protective index based on data on the tolerance of human tissue, developed by Stoll. Among the materials analyzed were fabrics made with flame-resistant cotton, rayon and wool; fabrics from glass and ceramic fibers; and fabrics from polyaramids, novoloids, modacrylic, polybenzimidazole and stabilized acrylic fibers.

Shalev,I. & Barker, R.L. (1984). Protective fabrics: a comparison of laboratory methods for evaluating thermal protective performance in convective/Radiant exposures. *Textile Research Journal*, 54, 648 - 654.

Keywords: 40,24,23,2,10,30,12,13,1,33,35,11,42,43
TESTING AND TEST METHODS, INSULATIVE PROPERTIES,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), ASBESTOS, COTTON,
MISCELLANEOUS F R FIBERS, F R FINISHES, F R WOOL (ZIRPRO),
ARAMID (NOMEX, KEVLAR), PBI, PHYSICAL PROPERTIES OF F R FIBERS,
DURABILITY OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES,
THERMAL PROTECTION,

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Abstract:
Two laboratory methods used to evaluate the ability of fabrics to provide protective insulation against high intensity thermal exposures are compared. These procedures are ASTM D4108-82, a method that uses a single laboratory gas burner as the heat source and a more versatile method that combines two gas burners and quartz heaters to provide a different mixture of radiant and convective heat. Comparisons are based on a series of tests made on a large group of specialized fabrics that might be used in the construction of protective apparel. Among the fabrics tested are samples made with flame resistant cotton, rayon and wool, fabrics from glass and ceramic fibers and fabrics from poly-aramids, cross-linked phenolics, modacrylics, polybenzimidazole and stabilized acrylic fibers. Differences in materials comparisons caused by the test procedure are discussed, especially the difference made by the balance of radiant to convective energy provided by the heat sources. Correlations are made with fiber and fabric properties. Special emphasis is placed on observing the performance of aluminized samples.

Shannon, E. & Reich, N. (1985). European study tour review of clothing and textile comfort research. *Proceedings of: ACPTC Combined Central, Eastern and Western Regional Meetings*, 197 - 204.

Keywords: 21,47,9,41,46,27,
GARMENT DESIGN, WEARING COMFORT, COMFORT ASSESSMENT, THERMAL / HEAT STRESS
WEAR STUDY METHODS, MANNEQUINS,

(Copy on file)

Abstract:
- developing new sizing systems, especially for handicapped and elderly, comfort research
- a climatic chamber temp. control from -20C to 50C, variable relative humidity, wind simulator and exercise bicycle and treadmill.
- thermal comfort no. 1, ease of wear no. 2 = of importance. ease of wear = weight and bulk of garment(s) and restrictions to body movement
- sensors used with resulting information transferred to a receiver. Recording hardware designed to fit in back-pack for field experiments
-testing equipment =skin-model, a thermoregulatory life size copper man (Charlie)
- 5 steps in physiological evaluation of clothing (least to most expensive): 1) skin test; 2) mannequin experiments; 3) controlled wear tests; 4) limited field test; 5) extensive field test

Shealy, O.L., Lynch, J.A. & Arnold, H.W. (1974). New flame resistant textile fibres. *Modern Textiles*, 55, 50 - 56.

Keywords: 18,11,35,30,43,
FLAMMABILITY, DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS,
MISCELLANEOUS F R FIBERS, THERMAL PROTECTION,

(NO Copy on file)

Abstract:
As a major producer of textile fibres, Du Pont has long recognized its obligation to provide products which offer performance, aesthetics and overall value to the consumer, while being as free as possible of potential problems. In recent years, the textile industry has been particularly concerned with potential problems of fabric and garment flammability. As a result, efforts have been accelerating to provide flame-resistant textile products where thereis a need for them. This paper describes three new flame-resistant fibres being developed by Du Pont to reduce the flammability of fabrics for apparel and home furnishings. These are a Dacron polyester staple, product, an Orlon modacrylic staple, and an Acele acetate filament yarn.

Shivers, J.C. & Hentschel, R.A.A. (1974). A new high temperature fiber. *Textile Research Journal*, 44, 665 - 669.

Keywords: 1,18,7,23,43,11,35,42,40,30,
ARAMID (NOMEX, KEVLAR), FLAMMABILITY, CHEMICAL RESISTANCE,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION,
DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS,
THERMAL PROPERTIES OF F R FIBRES, TESTING AND TEST METHODS,
MISCELLANEOUS F R FIBERS,

(NO Copy on file)

Abstract:
Nomex has found extensive application in protective clothing and high temperature industrial uses because of the excellent flame resistance, chemical and high temperature inertness of the fiber. Protection from flame by Nomex is a result of unique fiber and fabric behavior, which produces a thick protective char on exposure to flame. In certain catastrophic exposures (eg. total immersion in burning fuel in a lightweight garment) char formation does not occur, and protection beyond that of Nomex is desired. Fiber and fabric properties required to meet this new level of performance have been defined, and laboratory tests to simulate the exposure conditions have been formulated. A new high temperature fiber (HT-4) has been developed to meet these new requirements while retaining satisfactory textile performance.

Shvartz, E. & Benor, D. (1972). Heat strain in hot and humid environments. *Aerospace Medicine*, 43(8), 853 - 855.

Keywords: 41,45,
THERMAL / HEAT STRESS, VAPOUR BARRIERS,

(NO Copy on file)

Abstract:
Seven subjects attempted a 2-hour walk on a treadmill at 3.5 km/hour in 6 different environments of 25,30,35,40,45 and 50C each, while wearing vapor-barrier suits that simulated 100% relative humidity. Heat strainmeasurements and tolerance times were recorded. At 25C, all subjects completed the 2-hour work with negligible signs of heat strain, while tolerance times in the other conditions varied between less than 2 hours at30C to 28 minutes at 50C. Heart rate, skin temperature and sweat rate increased with a rise in room temperature. At room temperatures of 30C andhigher rectal temperatures reached similar levels but were lower at 25C. Tolerance time was found to be a function of body heat storage, and was alsorelated to skin temperature at 10 minutes of exposure.

Simms, D.L., & Hinckley, P.L. (1960). Protection against heat and flames. *Fire Research Special Report #3*, Joint Fire Research Organization, London.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Simms, D.L.. (1966). The design of test methods for industrial fabrics for protection against fire.. *Textile Institute and Industry*, 4(2), 43-44.

Keywords: 18,40,23
FLAMMABILITY, TESTING AND TEST METHODS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(NO Copy on file)

Abstract:

Skinner, J.S. (1985). Coping with heat stress on the fireground: fighting the fire within. *Firehouse*, (Aug.) 46 - 48, 66.

Keywords: 41,17,
THERMAL / HEAT STRESS, FIREFIGHTERS' PROTECTIVE CLOTHING,

(Copy on file)

Abstract:

Heat stress occurs when the body's temperature rises beyond safe limits. A heat load may result in minor muscle cramps, progressing to heat exhaustion and even to fatal heat stroke if the body temp. is not returned to normal. This article deals with: 1) coping with heat; 2) energy and fitness; 3) preventing heat stress; 4) effectiveness.

Smith, D.J. (1980). Protective clothing and thermal stress. *Annals of Occupational Hygiene*, 23, 217 - 224.

Keywords: 43,5,18,23,28,7,41,40,
THERMAL PROTECTION, BREATHING APPARATUS, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), METALLIZED FABRICS,
CHEMICAL RESISTANCE, THERMAL / HEAT STRESS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Experiment 1: A chemical/bacteriological suit made of moderately thick carbon impregnated felt was studied to determine thermal protection when wet and dry. Subjects were exposed to a hot climate on two consecutive days wearing C/B clothing that was either dry or regularly wetted and exercised by stepping on and off a 9 inch box at a rate of 12 steps/min. None of the subjects in the dry suit completed the exposure time limit while all but one of the subjects wearing the wetted suit reached the time limit before exceeding Tdb (deep body temp.) or heart rate limit.

Experiment 2: Garments to protect from ionizing radiation may be thermally restrictive when worn in hot environments. A cotton boiler-suit and a plastic coverall in combination with respiratory protection were studied.

Experiment 3: Exp. 2 showed that a man wearing a plastic suit has a limited time during which he can carry out any useful work. Radiant heat may also be encountered and a reflective cover may be advantageous. A limited staytime of 20 min. was provided by the plastic suit while the stripped control and the wetted cotton oversuit had staytimes extended to 50 min. or more. The protection afforded by the reflective cover varied with time and did deteriorate with the number of times worn. The sweat rate of the wetted suit was lower than that in the plastic suit with the stripped subject and the one with the reflective coating exhibiting even lower sweat rates.

Conclusions: If the humidity is low or moderate, wetting water absorbent material worn next to the skin or over water impermeable clothing extends the time an individual can work in the heat. The surface area over which evaporative cooling can take place is increased, reducing skin temperature and the rate of rise of deep body temp.; the strain on the body in terms of heart rate and sweat rate is also reduced.

Smith, E.E. (1976). Relation of performance tests to actual fires. *Fire Technology*, 12(1), 49 - 54.

Keywords: 40,18,
TESTING AND TEST METHODS, FLAMMABILITY,

(Copy on file)

Abstract:
This paper describes the evaluation of fire performance tests and their relation to real fires, not in terms of measurements and numbers obtained from the tests, but in terms of their conceptual design, significance, and theoretical limitations. Idealized test results will be assumed; the tests are compared on the basis of the best that can be expected from them.

Two general types of performance tests are considered, those that measure performance under a simulated fire exposure, and those that predict performance based on fundamental combustibility data. To evaluate these performance tests, the features of a fire system that should be compared are described, and criteria selected for judging the performance of the fire system and its components.

Smith, J. (1985). Comfort in casuals. *Textile Horizons*, 5(8), 35 - 38

Keywords: 47,9,40
WEARING COMFORT, COMFORT ASSESSMENT, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Assess and quantify sensorial comfort and describe the main factors that influence it.

A necessary step was to determine the specific skin sensations caused by next-to-skin apparel and to decide on a glossary of terms to describe these sensations. The physical and physiological factors that influence each sensation were then analyzed and, finally, simple test procedures were developed for evaluating a fabric or garment for a particular discomfort sensation (their development is not described here).

Smith, J.E. (1986). The comfort of clothing. *Textiles*, 15(1), 23 - 27.

Keywords: 46,47,9,21,
WEAR STUDY METHODS, WEARING COMFORT, COMFORT ASSESSMENT, GARMENT DESIGN,

(Copy on file)

Abstract:

A public questionnaire and wearer-trials are conducted at Shirley Institute to determine the discomfort sensations from fabrics and garments with emphasis on the importance of fabric aesthetics in creating the correct image for a garment. The response to the image will be to associate the fabric with past experiences which will ultimately influence the wearer's judgements of garment comfort.

This article looks at aspects the typical consumer considers when assessing a garment before purchase: aesthetics, handle, fit, suitability for the required end-use, and any past experience of similar fabric or garment, and then discusses the best methods of assessing a fabric or garment with respect to comfort.

Smollen, G. (1971). New ideas for turnout gear. *Fire Engineering*, 124(Dec.), 38.

Keywords: 43,18,17,28,21,14,7,26,47,41
THERMAL PROTECTION, FLAMMABILITY, FIREFIGHTERS' PROTECTIVE CLOTHING, METALLIZED FABRICS, GARMENT DESIGN, FABRIC CONSTRUCTION, CHEMICAL RESISTANCE, LEATHER, WEARING COMFORT, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
Firefighting gear should have high heat reflection, good visibility, be lightweight, have a long wear life and protect from chemicals and weather, and be low cost.

New gear developed, looking for lightness of weight, heat reflection, visibility and the elimination or alteration of D-ring and snap fasteners for easier donning and doffing. Features: Hypalon material (aluminized with reflective coating); large bellows pockets, reinforced, 1/3 made of leather, velcro to close them; underarms and shoulders tailored for freer movement, coat doesn't ride up as much when reaching; leather cuffs for better wear and elastic wristlets; double snap-out liners with vapour barriers - one summer, one winter; Velcro fasteners; collar lined with corduroy for wear and raised to provide more neck protection.

Velcro worked in both hot and cold weather - found needed Velcro end lower in neck area and have one snap fastener so wearer can have collar open without the Velcro scratching his chin.

Suggestion for footwear: cover the foot with a flexible steel mesh to protect the foot from puncture at any angle (not just sole of foot). Hard rubber or flexible metal should be used to protect foot from shin to steel toe from falling objects. Boots must not be heavy.

Snellen, J.W. (1969). Mean body temperature and the control of thermal sweating. *Acta Physiol. and Pharmacol. Neerl.*, 14, 99 - 174.

Keywords: 41,
THERMAL / HEAT STRESS,

(NO Copy on file)

Abstract:

Stanton, R.M., Schulman, S., & Ross, J.M. (1973). Evaluation of PBI and nomex II for air force flight suits. *AFML-TR-73-28.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Stanton, R.M., Schulman, S., & Ross, J.H. (1973). The protective characteristics of PBI and nomex coveralls in JP-4 fuel fires. *AFML-TR-72-253, 20.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Stanton, R.M. (1973). The response of PBI and nomex III fabrics exposed to a JP-4 fuel fire. *AFML-TR-73-37, 11 - 13, 23, 41 - 42.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Solomon, S.S. (1971). What color is best?. *Fire Chief Magazine*, 15, 42.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Soule, R.G., & Goldman, R.F. (1969). Energy cost of loads carried on the heat, hands and feet. *Journal of Applied Physiology*, 27, 687 - 690.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Spath, W. (1961). Impact testing of materials. London: Thames and Hudson.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Sprague, C.H. & Munson, D.M. (1974). A composite ensemble method for estimating thermal insulating values of clothing. *ASHRAE Transactions*, 80, 120 - 129.

Keywords: 24,41,43,40,
INSULATIVE PROPERTIES, THERMAL / HEAT STRESS, THERMAL PROTECTION, TESTING AND TEST METHODS,

(Copy on file)

Abstract:

1) Ensemble clo values may be estimate from garment clo values by simple formulas.

2) Area factors for complete ensembles may be estimated from the area factors for individual garments from a formula.

3) The simple formulas above will yield results which are sufficiently accurate for most engineering work.

4) Garment and ensemble data for use in these formulas and other purposes are given in tables 1 - 4.

Stanton, R.M. (1971). Heat transfer and flammability of fibrous materials. *AFML-TR-70-238.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Stanton, R.M. (1972). Evaluation of candidate materials for firefighters' proximity suits. *Technical Report AFML-TR-72-16.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Stephenson, J.E. (1983). Heat transmission of proban-treated fabrics subjected to a radiant heat source. *Fire and Materials*, 7(3), 123 - 127.

Keywords: 1,4,10,12,13,40,23
ARAMID (NOMEX, KEVLAR), BLENDS, COTTON, F R FINISHES, F R WOOL (ZIRPRO), TESTING AND TEST METHODS,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
Results of heat transmission testing of Nomex, polyester/cotton, Proban-treated (flame-resistant-treated) cotton, untreated cotton and wool workwear fabrics in the apparatus described in West German standard DIN 4842 are presented and discussed.

Stephenson, J.E. (1984). Flame-Retardant treatments for nonwoven and other textiles. *American Dyestuff Reporter*, 73(10), 47.

Keywords: 12,18
F R FINISHES, FLAMMABILITY,

(Copy on file)

Abstract:
This is a review ith 29 references.

Stephenson, J.E. (1985). Clothing for protection against heat and flame. *Textiles*, 14(3).

Keywords: 23,43,21,14,20,31,48,29,18,35,42,11,47,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, GARMENT DESIGN, FABRIC CONSTRUCTION, FOUNDRY WORKERS' PROTECTIVE CLOTHING, MOLTEN METAL EXPOSURE, WELDERS' PROTECTIVE CLOTHING, MILITARY PROTECTIVE CLOTHING, FLAMMABILITY, PHYSICAL PROPERTIES OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES, DURABILITY OF F R FIBERS, WEARING COMFORT,

(Copy on file)

Abstract:
Describes how protective clothing has developed in recent years by an examination of some of the hazards encountered in industry. Considers how these hazards may be overcome by an appropriate choice of natural fibers, fabrics, and garment design.

Foundries industry the choice of fabric to make protective clothing is determined by the metal being processed.

The choice of fabric and garment construction should reflect the correct degree of protection required by the job.

Welding, metal cutting, glass moulding, and boiler operations - demand the correct type of protective clothing which should also be issued to maintenance personnel in these industries.

Armed forces - clothing should cope with the secondary ignitions resulting from the effect of weapons (ships and aircraft). Clothing worn by service personnel should not be readily flammable and a contributor to the overall fire hazard.

Coal mines, oil refineries, natural gas installations, etc.. Fires can be initiated by ignition of the flammable material by a spark. Suitable clothing should be worn to minimize injuries resulting from direct flame and heat.

"Performance requirements of materials for flameproof clothing" BS 3120:1959.

"Materials and material assemblies used in protection against heat and flame." BS 6249:1982.

Foundries industry: "Assessment of the resistance of materials used in protective clothing to metal splash" BS 6257:1983.

Fabric used in protective clothing:
- must not itself contribute to the hazard
- must not ignite or sustain combustion from exposure to direct flame, molten metal splash, etc.
- must not melt away from the flame leaving a hole which exposes the flame directly to skin of the wearer.
- must not melt to produce hot sticky residues which can and do stick to the skin to produce severe burns.

- a garment should protect the wearer by preventing or restricting transmission of heat through itself (whatever the heat source)
- whatever the heat source, the fabric used to make the garment should remain intact.
- fabric should form a strong and stable char which will itself provide good insulation against the transmission of heat to the skin.
- the fabric should not shrink under the influence of heat to give a closer contact with the skin.
- molten metal splash - the metal should not stick to the fabric
-garment should be comfortable to wear particularly during long periods in conditions of high levels of heat.
- garment must be capable of regular and vigorous laundering to get rid of the inevitable soiling which occurs in the workplace
- oil and water repellent
- antistatic properties
- fabric for a protective garment should be selected on the basis that it has the correct construction and weight to meet the hazards of the job
- clothing should not have loosely fitting sleeves or pockets without flaps which could provide a trap for burning materials or molten metal drops

Stoll, A.M. & Greene, L.C. (1959). Relationship between pain and tissue damage due to thermal radiation. *Journal of Applied Physiology*, 14, 373 - 382.

Keywords: 6,23,43
BURN INJURY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION,

(Copy on file)

Abstract:

Stoll, A.M., Chianta, M.A. & Munroe, L.R. (1964). Flame-Contact studies. *Journal of Heat Transfer*, Series C, 86, 449 - 456.

Keywords: 40,18,23
TESTING AND TEST METHODS, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:

Stoll, A.M. & Chianta, M.A. (1968). Burn protection and prevention in convective and radiant heat transfer. *Aerospace Medicine*, 39, 1097 - 1100.

Keywords: 6,23,43,24,
BURN INJURY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, INSULATIVE PROPERTIES,

(Copy on file)

Abstract:

Experimental convection burn production is related to radiant burns and both of these to temperature rise measurements in a skin simulant of inert material.

Exposures were made in a controlled flame apparatus in which the heat flux remains constant while the exposure time may be set for any period.

Temp. rises were produced in a skin simulant covered by a series of protective assemblies. The heat flux at the skin surface was calculated. To compare the intensity-time values to those in literature for radiation burns in blackened skin, the exposure time was corrected for 31C rather than the 33C used. The radiant energy was then corrected to the amount absorbed by blackened skin and the agreement between the two was found to be very good.

Practical application in terms of the protection time afforded by a given material can then be made.
1) an exposure time is chosen and the temp. rise in the skin behind the material measured. Correlating the time to white-burn to the temp. rise of the skin on the graph, protection time for living skin can be read directly.
2) or the thickness of insulation can be derived for protection from thermal injury given the flux as there is a critical thickness of the outer layer beyond which the underlying layer exerts no effect on the surface temp. rise of the outer layer during absorption of energy at this surface.

Conclusion: Important is the equivalence in effect of flame contact and radiant heating. The experiment offers a means of studying directly the influence of the various optical properties of living skin since these affect heat transfer by radiation not convection since pigmentation is one of the primary controllers of the skin's optical properties, the effect of pigmentation may be investigated indirectly. Also, simple means of measuring burn protection capacity of clothing is realized.

Stoll, A.M. & Chianta, M.A. (1969). Method and rating system for evaluation of thermal protection. *Aerospace Medicine*, 40, 1232 - 1238.

Keywords: 43,40,6,
THERMAL PROTECTION, TESTING AND TEST METHODS, BURN INJURY,

(Copy on file)

Abstract:
Thermal protection rating systems for fabrics, based on pain and blister effects in human skin are considered in terms of: 1) precise evaluations applicable to any known temperature-time pattern and 2) simple laboratory procedures to provide a universally useful standard rating system. The first system which is more comprehensive is difficult and requires computer operations routinely; the second, described in detail, offers a rating system which is simple, directly related to pain and blister parameters and may be understood by the uninitiated as well as those knowledgeable in the field.

Stoll, A.M., Chianta, M.A. & Judge, A.B. (1971). Development of practical high-intensity thermal protection systems. *Aerospace Medicine*, 42(1), 48 - 54.

Keywords: 23,40,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
TESTING AND TEST METHODS,

(Copy on file)

Abstract:

Stoll, A.M., & Chianta, M.A. (1971). Heat transfer through fabrics as related to thermal injury. *Transactions New York Academy of Sciences Series II*, 33, 649 - 670.

Keywords: 6,43,18,23,24,
BURN INJURY, THERMAL PROTECTION, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES.

(NO Copy on file)

Abstract:

Flame Contact - 2 processes - convection and conduction - fabric heated by convection, skin by conduction. The heat transferred increases as the receiver is oriented more perpendicular to flames until a maximum of 90 degrees is reached. Convective transfer may be limited by air spaces between fabric layers, 4 mm is the optimum air space after which convection currents arise between layers causing the outer one to perforate.

Radiation - optical properties of fabric and skin affect heat absorption characteristics of system. Highly polished surfaces reflect total incident radiation preventing heat transfer through the fabric, however, ordinary long term use best served by dark colours and lightweight fabrics. Consider optical and thermal properties of fabrics, transmittance through fabric and spectral characteristics of the radiation.

Stoll, A.M., Munroe, L.R., Chianta, M.A., Piergallini, J.R. & Zaccaria, D.E. (1976). Facility and a method for evaluation of thermal protection. *Aviation, Space and Environmental Medicine*, 47(11), 1177 - 1181.

Keywords: 43,40,29,25,18,6,23,
THERMAL PROTECTION, TESTING AND TEST METHODS, MILITARY PROTECTIVE CLOTHING, JP-4 FUEL FIRES, FLAMMABILITY, BURN INJURY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),

(Copy on file)

Abstract:
The rationale, construction, operation, and protection assessment methodology of the Naval Air Development Center Fuel Fire Test Facility is described. The background and developmental progress to date are discussed. It is shown that the main difficulties associated with full-scale evaluation of fire-protective clothing have been identified and largely surmounted for present practical purposes. Evaluation can now be made reliably with a reasonably small number of prototypes. Modifications in apparatus and method can be made to provide for other studies. Future effort should be toward engineering development of scalar models on the one hand and, on the other, basic research into the depth of burns associated with thermal exposures to radiation and to flame contact: engineering effort on scalar modelling may greatly reduce the time and cost of obtaining valid burn protection assessments, thus bringing this capability into reach for many laboratories not now in a position to pursue these measurements; basic biophysical research may provide a valid experimental basis for extending prediction of burn effects by non-biological means to include depth of tissue injury, a feat not presently possible.

Stoll, A.M., Chianta, M.A., & Piergallini, J.R.. (1978). Heat transfer measurements of safety apparel fabrics. Naval Air Development Center, Report No. NADC-78209-60.

Keywords: 40,18,23,43
TESTING AND TEST METHODS, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION,

(NO Copy on file)

Abstract:

Stull, J.O. (1985). Criteria for the selection of candidate chemical protective clothing materials. *Journal of Industrial Fabrics*, 4(2), 13 - 22.

Keywords: 7,37,40
CHEMICAL RESISTANCE, REGULATIONS AND STANDARDS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Requirements established by the U.S. Coast Guard service for new materials which give protection against chemicals are described in terms of necessary physical properties, resistance to chemicals and acceptable methods of manufacture. These requirements pertain to total encapsulation suits. American Society for Testing and Materials (ASTM) and Federal Standard methods used in material evaluation are cited.

Summers, T.A., Bivin, R.J., Finley, E.L. & Cochran, B.J. (1976). Heat absorbed by surface sensors from multilayer garments as affected by fiber, finish and conformation. *Journal of Consumer Product Flammability*, 3, 268.

Keywords: 16,43,8,21,27,23,18,12,
FABRIC SYSTEMS, THERMAL PROTECTION, CLOTHING SYSTEMS, GARMENT DESIGN, MANNEQUINS, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, F R FINISHES,

(Copy on file)

Abstract:
Multilayer garment arrangements were tested on a fireproof mannequin. In phase I, surface heat absorbed was determined by burning a non-FR dress over an FR slip. All-cotton and 70/30 cotton-polyester slips treated with THPOH-NH3 had lower surface heat absorbed than untreated slips.

In phase II surface heat absorbed was determined for non-FR dresses, belted and unbelted at the waistline, used over nylon full length and half length slips. Garment combinations of all-polyester dresses and nylon slips did not burn. Cotton dresses over the nylon slips burned vigorously. Belts temporarily retarded flame advance. Less surface heat absorption occurred where space existed between the garments and the garments and the mannequin.

Sund, J.L. & King, R.R. (1983). Longitudinal wear study of four work shirts in ferrous metal operations; king county, washington. *Fire Technology*, 19(3), 163 - 169.

Keywords: 43,31,11,35,18,23,6,46,1,10,13,47
THERMAL PROTECTION, MOLTEN METAL EXPOSURE, DURABILITY OF F R FIBERS, PHYSICAL PROPERTIES OF F R FIBERS, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), BURN INJURY, WEAR STUDY METHODS, ARAMID (NOMEX, KEVLAR), COTTON, F R WOOL (ZIRPRO), WEARING COMFORT,

(Copy on file)

Abstract:
Metal Trades - abrasion resistance; tear strength; ultraviolet irradiation; flammability; molten metal splash resistance; spark resistance

Methodology:

A) Initial Questionnaire - directed toward buying practices (price, fiber content, knowledge of FR garments and desirable qualities); dealing with work environment and burn history of individual - all dealt with sparks, molten metal splash, dry heat, extreme temperatures, ultraviolet and infrared radiation; burn injury common

B) Analysis of Statistics - upper body injuries most common, therefore work shirts greatest potential for increasing wearer safety

C) Market Survey - availability of fire resistant fabrics and fibers: Nomex III aramid, Firestop cotton, Flamepro wool, 100% untreated cotton

D) Wear Test - to determine protective and wear-life performance; to determine consumer satisfaction based on comfort, protection and acceptability.
Results:
No loss of fire resistance after laundering to any shirts
Loss of tear strength - Nomex, Firestop cotton, untreated cotton - attributed to degradation of fibers because of continuous exposure to ultraviolet radiation in the welding operation
Burn damage - Fire Resistant Wool - surface burns; Nomex III - pinhole size burns; Untreated Cotton - spark burns; Fire Resistant Wool and FIrestop cotton had under 5 burns per shirt; Nomex - 9; Untreated cotton - 11. (Class 3 and 4 - spark burns not larger than 1/4 inch - burns of significant size or larger than 1/4 inch - taken into account as cause most burn potential)

E) Final Questionnaire - directed toward comfort, appearance, protection, acceptability; comfort - untreated cotton and Nomex rated equally most comfortable, Fire Resistant wool last; appearance - Fire Resistant wool first, FR cotton rated last; protection - FR cotton first, Nomex last

Twelve weeks - each shirt had 15 wear cycles (worn for 1 work shift then laundered at U of Wash under controlled conditions)

Teichner, W.H. (1948). Assessment of mean body surface temperature.. *Journal of Applied Physiology*, 12, 169-176.

Keywords: 49
BODY TEMPERATURE MEASUREMENT,

(NO Copy on file)

Abstract:

Teitlebaum, A., & Goldman, R.F. (1972). Increased energy cost with multiple clothing layers. *Journal of Applied Physiology*, 32, 743 - 744.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Tesoro, G.C. & Rivlin, J. (1971). Flammability behavior of experimental blends. *Journal of Textile Chemists and Colorists*, 3(7), 156 - 160.

Keywords: 18,4,14,40,1,10,
FLAMMABILITY, BLENDS, FABRIC CONSTRUCTION, TESTING AND TEST METHODS, ARAMID (NOMEX, KEVLAR), COTTON,

(NO Copy on file)

Abstract:
Knitted fabrics of controlled construction have been prepared from experimental yarns to evaluate the effects of fiber composition on flammability for two-component blends containing varying amounts of nonflammable fibers. The limiting oxygen index (LOI) of these structures has been determined, and LOI values corresponding to self-extinguishing behavior the vertical flame test (AATCC Test Method 34-1966) have been noted. In blends of a flame retardant fiber with a combustible fiber, the amount of the flame-retardant component required to obtain self-extinguishing behavior in the fabric is generally greater than calculated by averaging the LOI's of fabrics made from the component fibers in 100% form. The effect of finishing treatments designed to further decrease flammability has been explored on blends of cotton with Nomex. The results of this work have indicated several factors which must be considered in the design of self-extinguishing fabrics from blends containing a nonflammable fiber.

Thompson, T. (19xx). Full-Scale tests establish fire resistance. Source unknown.

Keywords: 43,18,23,24,16,10,1,13,21,40,15,12
THERMAL PROTECTION, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), INSULATIVE PROPERTIES,
FABRIC SYSTEMS, COTTON, ARAMID (NOMEX, KEVLAR), F R WOOL (ZIRPRO),
GARMENT DESIGN, TESTING AND TEST METHODS, FABRIC IGNITION TIME,
F R FINISHES,

(Copy on file)

Abstract:

Ideal flame retardant garment should not ignite nor propagate flame and should impede the passage of heat through the fabric to the skin. It should resist the penetration and absorption of flammable liquids and retain FR properties when subjected to repeated cleaning, be durable, comfortable, cause no skin irritation and should cost much more than conventional workwear.

Formation of char desirable as it may inhibit the release of flammable gases and may form a thermally insulating cover for underlying surfaces.

Air is a good thermal insulator and should be incorporated in weaving, knitting, the use of several fabric layers or making use of the porous nature of fibers.

Thermoplastic fibers should be avoided in garments as they melt and cause burns and the fiber debris can be introduced into the damaged tissue. The melted material may also fuse together various garment layers and thus destroying the air gap and insulative value.

An efficient thermal barrier may also prevent the escape of body heat which may cause exhaustion or collapse. Thus, a compromise is necessary.

Tested 9 fabrics for ease of ignition, rate of flame propagation, ability to transmit heat, degree of oil penetration, absorbency, durability to repeated laundering, tear strength and resistance to abrasion.

For general use, Proban treated cotton drill or Nomex III (300g/m**2)

Good heat insulation plus flame retardance - single piece material (450g/m**2) like wool blended with FR viscose or Zirpro Wool or general purpose coverall supplemented in vulnerable areas by heavyweight materials.

Correct fit, good design and provision of appropriate accessories necessary.

Found FR characteristics of all but wool and wool blends were destroyed by oil presence above 15% which is hard to detect by rinses.

Chemical FR are destroyed unless washed following instructions

Trent, L.C., Resch, W.A., Coppari, L.A., & Finley, D.L. (1979). Design and construction of a thermally-instrumented mannequin for measuring the burn injury potential of wearing apparel.. *Textile Research Journal*, 48, 639-647.

Keywords: 6,18,23,27,40,
BURN INJURY, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), MANNEQUINS,
TESTING AND TEST METHODS,

(Copy on file)

Abstract:
In recent years interest has grown in tests that predict injury potential by measuring the heat transferred from burning textile materials. The preferred test is one in which the geometry of the heat receiver closely approximates the form of the human body. This work describes the design and construction of a heat-sensing system capable of measuring the area of simulated first-, second-, and third-degree burns of the human body. Sufficient detail is included to allow construction of similar mannequin systems by others.

Tschirch, R.P., Sidman, K.R., & Arons, I.J. (1984). Heat-resistant protective hand covering. USP 4,454,611:19, (Patent).

Keywords:

(Copy NEVER VIEWED)

Abstract:
A glove is made of temperature-resistant aromatic polyamide fibres with a flame-resistant elastomer coating on the outer surface. The liner comprises a felt made from temperature-resistant aromatic polyamide fibres.

Turner, J.M. (1976). Fire department involvement in research and development of firefighter protective clothing and equipment. *Conference on Protection for Firefighters*, ITT Research Institute, Chicago.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Tweedie, A.S., Mitton, M.T. & Wiles, D.M. (1971). Rate-of-Burning measurements and evaluation of fabric flammability. *Canadian Textile Journal*, 88, 73 - 88.

Keywords: 40,18,14,
TESTING AND TEST METHODS, FLAMMABILITY, FABRIC CONSTRUCTION,

(NO Copy on file)

Abstract:
Rate-of-burning tests were carried out on a wide variety of commonly used fabrics. Two methods using vertical strips of pre-dried fabric were compared: 1) Canadian Method 27.3:1962 (with minor changes); 2) a proposed modification of (1) with specimen frame. The relationship between values obtained by the two methods varies basically with the fiber type. The first method is preferred for simplicity and because less fabric is required.

Each method yielded data showing for the majority of fabrics within each fibre type examined, a fabric weight/burning rate relationship(s) characteristic of normal burning behavior. Fabrics burning faster than the norm could be identified by either method, and the significance of this assessed. The five fabrics (out of 117) having abnormally faster rates of burning were also identifiable by the AATCC 45 degree angle test but, in general, this test provides less information.

Fabrics from some body-burn and other fire-involvement cases are described and their flammability evaluated by relating their weight, fiber content, and rate of burning to the established normal burning patterns. The need for more and better safety education is emphasized.

Utech, H. (19xx). Status report on research programs for firefighters protective clothing. *Proceedings of the 45th Annual Fire Department Instructors' Conference.*

Keywords:

(Copy NEVER VIEWED)

Abstract:

Utech, H.P. (1972). Injuries show what protection improvements clothing should offer. *Fire Engineering*, 125, 47 - 49.

Keywords: 43,17,21,23,18,16,8,44,47,31,7,14,11
THERMAL PROTECTION, FIREFIGHTERS' PROTECTIVE CLOTHING, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FLAMMABILITY, FABRIC SYSTEMS, CLOTHING SYSTEMS, UNDERWEAR, WEARING COMFORT, MOLTEN METAL EXPOSURE, CHEMICAL RESISTANCE, FABRIC CONSTRUCTION, DURABILITY OF F R FIBERS,

(Copy on file)

Abstract:

Protective clothing and equipment provide protection at the fire scene where most injuries occur. There are five major hazards faced by firefighters.

The leading cause of injury at the fire scene are caustic, toxic and noxious substances.

Smoke inhalation is a problem, as is absorption and ingestion of substances.

There is significant incidence of absorption through the skin of which nearly half are chemical burns.

Although striking and being struck by objects are the most frequent causes of injury, only the helmet is designed for protection when other parts of the body are also susceptible. 1/3 of all fractures due to striking or being struck by objects - high number of injuries due to glass.

Overexertion is the third most frequent cause of injury the consequence of which is usually a sprain or strain but also heart attack, hernia or rupture most frequent source is the firehose.

Falls cause injury to lower extremities. Strategically placed padding could help to distribute the force of the fall and thus reduce injury.

Injuries from high temperatures and hot objects. Large number of head and neck injuries - portions of head, especially ears left uncovered.
Dress or apparel judged hazardous in 25.5% of the injuries - inadequate masks, gloves, goggles and boots.

1) Respiratory protection remains the firefighter's foremost problem.
2)Physical demands must be reduced - reduce weight, bulk, resistance to body movement of present clothing and equipment - improve removal of metabolic heat.
3)Better impact protection needed for head and other body areas.

Utech, H.P. (1973). High temperatures vs. fire equipment. *International Fire Chief*, 39(10), 26 - 27.

Keywords: 43,23,17,18,
THERMAL PROTECTION, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY,

(Copy on file)

Abstract:

Much equipment used by firefighters performs badly at the high temperatures to which they are subjected (ie. on the market are turnout coats which shrink and burn, helmets and faceshields which melt and ladders that soften).

Polycarbonate plastics used in helmets are not meant to be used above 250F, soften at 320F, while firemen in complete turnout gear can withstand temperatures in excess of 400F. On direct flame contact, polycarbonate helmets are more severely damaged and may cause burns.

Some turnout coats are made from fabrics with little or no flame resistance.

Aluminum ladders will melt at elevated temperatures and above 350F its strength is reduced although it may not show visible signs of damage.

One reason for inadequate equipment on the market is the lack of testing of materials for realistic high temperature performance. The equipment should be subjected to the same thermal conditions firefighters encounter.

Radiant heat - emitted from the fire and all heated surfaces and objects.

Convective heat - from hot air and gases (carried by)

3 fire conditions:
1) Routine - one or two objects in a burning room - firefighting equipment has no trouble in this condition.
2) Ordinary - more serious fire ie. next door to a flashed-over room. The fireman should be able to function for 20 to 30 minutes ie. just long enough to put out the fire or until 30 minute air supply is gone. Thus, equipment must also be able to function in this condition for this time length without damage.
3) Emergency - flash-over - Coat should function for 15 - 30 sec. or long enough for escape with minimum injury. The clothing may suffer damage in this condition as long as the man is protected.

Utech, H.P., Fourt, L. & Hollies, N.R.S. (1974). Firefighter's turnout coat: a design analysis. *Journal of Safety Research*, 6(1), 2 - 14.

Keywords: 17,18,23,21,47,11,40,24,43,6,37
FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), GARMENT DESIGN,
WEARING COMFORT, DURABILITY OF F R FIBERS, TESTING AND TEST METHODS,
INSULATIVE PROPERTIES, THERMAL PROTECTION, BURN INJURY,
REGULATIONS AND STANDARDS,

(Copy on file)

Abstract:
The performance requirements for a firefighter's turnout coat are broken down into 5 major categories: hazard protection, comfort, durability and wear, appearance and visibility and other requirements. Appropriate test methods for measuring each performance requirement are identified and discussed. Suitable test methods are found to be lacking in several key areas, including impact protection and thermal insulation. The design and performance of present turnout coats are evaluated in terms of the performance requirements. These requirements and available test results on coats now in use are related to and interpreted in terms of firefighter evaluations, injury statistics and the existing literature.

Vancott, H.P., & Kinkade, R.G. (1972). Human engineering guide to equipment design. Washington, D.C.: U.S. Government Printing Office.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Veghte, J.H. (1973). Human exposure to high radiant environments. *Aerospace Medicine*, 44, 1147 - 1151.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Veghte, J.H. (1982). Current and future design concepts for firefighter protective clothing. *Fire Chief Magazine*, (Jan.).

Keywords: 17,18,21,23,14,16,31,44,47,7,11,42,43
FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FABRIC CONSTRUCTION, FABRIC SYSTEMS, MOLTEN METAL EXPOSURE, UNDERWEAR, WEARING COMFORT, CHEMICAL RESISTANCE, DURABILITY OF F R FIBERS, THERMAL PROPERTIES OF F R FIBRES, THERMAL PROTECTION,

(Copy on file)

Abstract:

Considerations: type of fire exposure, level and duration of temperature exposure, need for proximity or turnout protective clothing. (Proximity for exposure to high temperatures - close range, turnout for structural firefighting).

Outer layer most important as exposed, it must resist slashing and tearing, extreme abrasion, molten metals, acids and other chemicals.

The garment should be lightweight, moisture retention adds weight so use coated fabrics in colder climates.

A multi-layer system incorporates air spaces for insulation.

Need air ventilation to prevent heat stress.

Neither underclothing nor skin should be exposed when crouching, bending or reaching, the coat must overlap the pants, sleeves must provide maximum arm movement and special attention should be given to the wrist seal which must prevent water running in the sleeves when arms are raised. Long wristlets and gloves will provide excellent thermal and slash protection for the forearm, wrist and lower hand. A high collar with multi-layer construction - must protect against hot water, embers, hot gases - should be shaped to merge with helmet.

Need vapour barrier (beneath outer shell) to prevent the loss of thermal insulation characteristics - moisture results in greater heat conduction.

Thermal liner (under vapour barrier) protects against extremes in temperature.

May be another vapour barrier within the thermal liner to absorb sweat.

Veghte, J.H. (1982). Designing protective clothing. Part 1. *Fire Service Today*, (March).

Keywords: 23,43,21,18,17,41
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL PROTECTION, GARMENT DESIGN, FLAMMABILITY, FIREFIGHTERS' PROTECTIVE CLOTHING, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
Firefighter protective clothing often chosen because of appearance, colour, fit and low cost rather than on the basis of physiology, heat transfer characteristics and real dollar value.

HT-1, Nomex, Kevlar, PBI are all being considered for protective clothing.

Firefighters encounter dangerous temperatures from the radiant heat energy of a JP-4 fuel flame (1800F) to a radiant/convective heat mixture of a smoky structural fire (200 - 600F).

Under great thermal loads, the outer material of the turnout becomes critical - it will only protect for a very short time

Factors which determine the amount of heat transferred by thermal radiation are: the temperature difference between the two surfaces, their distance from each other and the reflectivity of each surface. Radiative heat transfer doesn't depend on air temperature between the surfaces or the colour of the clothing.

Heat transmission by convection depends on the movement and density of surrounding gases or liquids - normally air or water.

Conduction is increased if clothing is wet or compressed.

Veghte, J.H. (1982). Designing protective clothing. Part 2. *Fire Service Today*, (April).

Keywords: 17,18,21,23,41,43,24,45,16
FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, GARMENT DESIGN, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), THERMAL / HEAT STRESS, THERMAL PROTECTION, INSULATIVE PROPERTIES, VAPOUR BARRIERS, FABRIC SYSTEMS

(Copy on file)

Abstract:

Outershell must: resist slashing, tearing, extreme abrasion, common chemicals, be lightweight even when wet, provide thermal protection, not be affected by laundering, have low shrinkage (if too tight, heat transfer is increased)

Moisture or Vapour Barrier must: prevent the loss of thermal insulating characteristics, prevent water penetration (causes heat path), shut out steam and prevent weight gain, be lightweight and flame-retardant

Thermal Liner must: be lightweight and flame retardant, protect against extreme heat and cold and the high radiant heat load of the fire environment

Second Vapour Barrier (in thermal liner) must: reduce moisture from sweating

Air layer (no more than .71 inch) must: insulate the wearer - fundamental to design

Firefighters need protection from by-products of the fire environment: cold, steam, water, direct flame contact.

Veghte, J.H. (1982). Designing protective clothing. Part 3.. *Fire service today,* (May).

Keywords:

(Copy on file)

Abstract:

Veghte, J.H., Smedley, D.C. (1982). S.A.F.E. analyzes protective gear.. *Fire Service Today,* September 1982, 26-28.

Keywords:

(Copy on file)

Abstract:

Safety Analyses of Fire Fighter's Ensembles (S.A.F.E.) is a computer program that allows the user to create his own simulated fire situations and protective clothing ensembles. This program tests the thermal protective qualities of existing and experimental turnout clothing. It can predict the amount of time available for fire fighting before second degree burns and/or initial fatigue occur. These predictions rate the effectiveness of the thermal protective clothing the user has selected.

Veghte, J.H. (1983). Protective clothing survey results. *Fire Service Today*, (Aug.).

Keywords: 43,21,17,18,22,41,
THERMAL PROTECTION, GARMENT DESIGN, FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, GLOVES, THERMAL / HEAT STRESS,

(Copy on file)

Abstract:
This survey points to the following area of protective clothing design or concepts that should be improved.

1) Most thermal injuries occur to the firefighter's face and hands. Therefore, manufacturers should try to improve the thermal protective design of face shields and gloves.

2) The shoulder, elbow, and knee regions of the outer shell are high wear areas and should be reinforced with additional material. Pockets were reported to have many tears or rips.

3) Sweating or water leakage into clothing, as well as icing, are serious problems associated with fighting fires. Manufacturers should address these problems through improved design concepts.

4) Coat pockets should be positioned so that they are accessible to the firefighter even when the SCBA torso strap is fastened.

5) One-third or more of the firefighters feel hot or very hot while wearing their protective clothing in the summer. Ways of reducing this physiological stress on the firefighter should be explored.

6) Surveys of this type should be conducted periodically to alert manufacturers to the need for better design features in protective equipment for structural firefighters.

Veghte, J.H. (1984). Testing water barriers in protective clothing. *Firehouse*, (Sept.), 36 - 38.

Keywords: 17,47,45,41,46,40,
FIREFIGHTERS' PROTECTIVE CLOTHING, WEARING COMFORT, VAPOUR BARRIERS, THERMAL / HEAT STRESS, WEAR STUDY METHODS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
Ideally, a firefighter needs a material that serves as a semipermeable barrier, allowing water vapor (sweat) to exit and preventing water from entering. The GORETEX membrane, expanded polyterafluorethylene (PTFE), is such a material. Laboratory tests have established the selective permeability of the PTFE to water vapor. The article is a study conducted, involving five firefighters, attempting to answer the question, "Does the GORETEX barrier really provide a significant physiological difference to the firefighter in a relevant fire scenario? Or are the differences seen in the laboratory studies valid but physiologically meaningless for the firefighter?"

Describes in detail the test method gone about - using firefighter facility and running through evolutions.

Test Results: Under the field conditions endured, the data clearly shows the physiological advantages of using GORETEX over Neoprene.

Veghte, J.H. (1986). Design criteria for fire fighters protective clothing. Dayton, Ohio: Janesville Apparel Division of Lion Uniform.

Keywords: 47,23,21,17,18,6,41,8,14,16,11,37,
WEARING COMFORT, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), GARMENT DESIGN, FIREFIGHTERS' PROTECTIVE CLOTHING, FLAMMABILITY, BURN INJURY, THERMAL / HEAT STRESS, CLOTHING SYSTEMS, FABRIC CONSTRUCTION, FABRIC SYSTEMS, DURABILITY OF F R FIBERS, REGULATIONS AND STANDARDS,

(Copy on file)

Abstract:
CONTENTS
- Protective Clothing Development
- The Fire Environment
- Three Ways Heat is Transferred
- The Burn Threshold
- The Body's High Temp. Response Mechanisms
- The Body's Internal Response to Heat
- Functional Design Requirements for Protective Clothing Fabrics
- Functional Design Requirements for Protective Clothing Construction: Pant Design Criteria, Coat Design Criteria, Design Conclusions

APPENDIX I: OUTLINE OF NFPA 1971 STANDARDS AND OSHA 1910, Subpart L
APPENDIX II: HOW TO WRITE PROTECTIVE CLOTHING SPECIFICATIONS J.H. GRANBY (ed)

Vickers, A.J., Krasny, J. & Tovey, H. (1973). Some apparel fire hazard parameters. *Information Council on Fabric Flammability, Proceedings of the Seventh Annual Meeting*, New York City, 205 - 226.

Keywords: 18,21,14,10,6,
FLAMMABILITY, GARMENT DESIGN, FABRIC CONSTRUCTION, COTTON, BURN INJURY,

(Copy on file)

Abstract:

Flammability characteristics of garments include ease of ignition, flame spread rate, heat transfer to the skin, ease of extinction which are influenced by fiber content, fabric weight and construction, surface characteristics and garment configuration and fit.

Fiber content, burn time and garment configuration and fit are studied with relation to frequency of involvement and extent of injury. Only first-to-ignite garments not contaminated by flammable liquids are considered.

The majority of the garments contained cotton - cellulose and cellulosic blends; 1/2 victims suffered minor burns; 1/4 extensive burns (over 20% body); single layer thermoplastic fabrics caused less serious burns than the cellulosics but multi-layer, 100% thermoplastic fibers in outer layer with polyester or cotton lining or batting resulted in severe injuries; higher burn times are associated with heavier materials however fiber content and construction must be taken into account.

Effect of Burn Time on Burn Injury: the proportion of extensive vs. less extensive burns does not vary to a great extent over burn time (fabric weight) groups with the exception of very heavy, slow burning fabrics. The higher flame spread rate of the lighter fabrics may be balanced by the greater heat output and greater difficulty in extinguishment of the heavy fabrics. The formation of heat chimneys also transfers heat generated to other parts of the body producing larger burn areas.

Garments: pants, shirts least severity - pants higher as fabric heavier so harder to ignite and legs form good heat chimneys; dresses, nightgowns, robes most severe - looser fitting so form excellent heat chimneys

Vokac, Z., Kopke, V. & Keul, P. (1971). Effect of cooling of peripheral parts of the body on general thermal comfort. *Textile Research Journal*, 41, 827 - 833.

Keywords: 47,41,9,24,
WEARING COMFORT, THERMAL / HEAT STRESS, COMFORT ASSESSMENT, INSULATIVE PROPERTIES,

(Copy on file)

Abstract:
The Scandinavian cross-country ski dress covers only about 2/3 of the body surface area (trunk, arms and thighs). The peripheral area (head, hands, legs and feet) is covered by garments which are not an integral part of the dress. Selective cooling of the peripheral area in six subjects in a climatic chamber showed that a general feeling of being cold was achieved by lowering the skin temperature in the peripheral area. The same general thermal sensation was also arrived at by keeping the peripheral area warm and cooling the central skin area. The general thermal sensation was related to the average weighed skin temperature, irrespective of the location of the cold and warm surface areas. In the evaluation of thermal comfort of any clothing system, attention should be paid to the insulation of the parts of the body which are not covered by the garments under investigation.

Vokac, Z., Kopke, V. & Keul, P. (1972). Evaluation of the properties and clothing comfort of the scandinavian ski dress in wear trials. *Textile Research Journal*, 42, 125 - 134.

Keywords: 41,47,9,46,
THERMAL / HEAT STRESS, WEARING COMFORT, COMFORT ASSESSMENT, WEAR STUDY METHODS,

(NO Copy on file)

Abstract:

Vokac, Z., Kopke, V. & Keul, P. (1973). Assessment and analysis of the bellows ventilation of clothing. *Textile Research Journal*, 43, 474 - 482.

Keywords: 41,47,9,46,
THERMAL / HEAT STRESS, WEARING COMFORT, COMFORT ASSESSMENT, WEAR STUDY METHODS,

(Copy on file)

Abstract:

A methodical approach is described, attempting to separate the loss of heat and moisture due to forced exchange of air inside clothing, when walking, from the loss caused by gradients between the body and the environment.

Temperature, heat flow, and relative humidity were recorded on the skin of the back and inside the respective clothing (shirt only, vest and shirt, or vest, shirt and anorak) in 12 experiments performed in a climatic chamber at 4 - 11C and 35 - 70% RH. The subject walked on a treadmill with 5% grade at 7.2 km/hr until a new steady state of higher temperature and heat flow, as well as humidity, resulting from evaporation of sweat, was reached. When the motion was suddenly stopped, both the temperature and humidity increased steeply, while the heat flow decreased, showing levels which would have been attained, theoretically, if the transfer of heat and water vapor along gradients was not assisted by forced exchange of air when walking. When walking was resumed after a pause, all recorded parameters changed in the opposite direction. Continuous recording of temperature next to skin showed temperature oscillations synchronous either with every step or with every other step.

The results are considered as evidence of the effect of force ventilation on the microclimate. Calculated from changes in water-vapor pressure, the magnitude of forced ventilation corresponded, approximately, to dilution of the air layer next to skin, with atmospheric air, by one-half of its volume.

It was demonstrated, in addition, that the heat of sorption, arising from transient increases of humidity in the clothing had a marked effect on temperature of the micro-climate.

The term "bellows ventilation" is thought to express best the mechanism of exchange of air resulting from rhythmical movements of limbs and body at physical activity.

Vokac, Z., Kopke, V. & Keul, P. (1976). Physiological responses and thermal, humidity and comfort sensations in wear trials with cotton and polypropylene vest. *Textile Research Journal*, 46, 30 - 38.

Keywords: 46,47,41,9,44
WEAR STUDY METHODS, WEARING COMFORT, THERMAL / HEAT STRESS, COMFORT ASSESSMENT, UNDERWEAR,

(Copy on file)

Abstract:

Relations were studied between skin temperature of the back as well as temperature and humidity inside clothing and subjective estimates of thermal, humidity and comfort sensations in 5 subjects wearing cross-country ski dress. The 2-h wear trials were performed in a climatic chamber at -2C and simulated the actual circumstances under which such a dress is worn by alternating periods of intensive walking (20 min.) on a treadmill with periods of resting (5 - 10 min.). Each subject participated in 4 trials wearing alternately one of the 4 experimental, double-layer vests (double-cotton, cotton-polypropylene with cotton layer next to skin, same combination with polypropylene layer next to skin, double-polypropylene).

Skin temperature of the back was during the experiments systematically lower ($P<0.05$) by about 1C with the double-layer cotton vest than with the double-layer polypropylene vest. Since the physical parameters of the two fabrics were not identical, the findings cannot be definitely attributed to the inherently different properties of the fibers. No significant differences were found in the 4 experimental series either in other objective measurements (temperature and humidity of the microclimate, energy output, total amount of sweat, amount of sweat trapped in the vests) or in subjective estimates of thermal, humidity, and comfort sensations.

Gradual increase of skin temperature as well as of temperature and humidity (sweating) of the microclimate was recorded during walking periods. When walking was interrupted by a pause, both the temperature and humidity rose steeply due to the cessation of bellows ventilation of the clothing, and fell again when walking was resumed. The thermal and humidity sensations on the back reported after the turning-points of the intermittent activity showed opposite direction of changes than those of the recorded parameters - ie. decrease during pauses and increase after walking was resumed. It is possible that the perception of local sensations was affected by superimposed, central perception of changes in the amount of heat delivered from muscles to the brain receptors. The sensations of comfort seemed to be affected mostly by perception of "warmth" when walking and "cold" when resting.

Wachtel, T.L., Knox, F.S., & McCakran, G.R. Jr. (1978). A porcine bioassay method for analysis of thermally protective fabrics: a clinical grading system. Fort Rucker, Al: U.S. Army Aeromedical Research Laboratory, *USAARL Report 78-8*.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Ward, D. (1982). Industrial textiles. promoting the 'Comfort zone'. *Textile Month*, (Aug.), 17.

Keywords: 34,7,47,
PESTICIDE PROTECTIVE CLOTHING, CHEMICAL RESISTANCE, WEARING COMFORT,

(NO Copy on file)

Abstract:
Kimberly-Clark Corporation has launched a series of composite fabrics for protective clothing which is breathable and comfortable to wear. SafeGuard CPF is a composite formed by two layers of spunbonded polypropylene sandwiching a layer of melt-blown polypropylene fibres. DuraGuard protective fabrics are spunbonded fabrics based on polypropylene filaments. DisposaGuard scrim-reinforced cellulosic materials with nylon filaments bonded to a cellulosic web.

Warden, J. (1982). Firemen's uniforms - the case for establishing a common standard. *Fire*, 74(919), 427.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Wardle, M.W. (1977). High performance coated fabrics of Kevlar aramid fiber. *Journal of Coated Fabrics*, 7(July), 3 - 23.

Keywords: 1,35,11,
ARAMID (NOMEX, KEVLAR), PHYSICAL PROPERTIES OF F R FIBERS,
DURABILITY OF F R FIBERS,

(NO Copy on file)

Abstract:
Kevlar aramid fibers offer a highly desirable balance of properties which have found utility in a wide range of applications, such as tire cord, hose reinforcement, conveyer belts, ropes and cables, protective clothing, boat hulls and aerospace composites. This paper will focus on the use of Kevlar aramid fibers in high performance coated fabrics and will compare the mechanical properties of coated fabrics based on Kevlar 29, polyester, nylon and glass fibers.

Watkins, D.A (1982). Military market for fire retardant textile materials in canada. In *Progress In Fire Safety: Regulations, Polymers, Chemicals, Markets.* (pp. 187-194) (Fire Retardant Chemicals Association) Technomic Publishing Co.

Keywords: 18,29,7,23,11,43,47,
FLAMMABILITY, MILITARY PROTECTIVE CLOTHING, CHEMICAL RESISTANCE, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), DURABILITY OF F R FIBERS, THERMAL PROTECTION, WEARING COMFORT,

(Copy on file)

Abstract:
Need to provide protection against chemical and nuclear attack, camouflage against various surveillance threats and a high level of durability of both the material and its characteristics.

Need improvements in thermal resistance properties for operational clothing and equipment.

Constraining requirements which include cost, comfort and durability.

Classification Structure:
a) Low risk applications - dress uniforms, general work clothing and recreational clothing
b) Moderate risk applications - general combat clothing
c) High risk applications - clothing for aircrew, combat vehicle crewmen, sailors, as well as, aircraft, shipboard and vehicle upholstery.
d) Extreme risk applications - firefighters' clothing, special garments worn by industrial workers - welders, fuel handlers, etc.

Attention must be paid to the durability of the FR properties. The effect of the change on strength, durability, camouflage, water repellency, chemical protection, comfort, and so on, must be assessed. Cost must also be considered.

Watkins, S.M., Valla, M.K., & Rosen, L.R. (1978). The development of two protective apparel systems for firefighting. Washington, D.C.: Government Printing Office, PB80-216310, National Fire Prevention and Control Administration, U.S. Department of Commerce.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Watkins, S.M. (1984). Clothing - the portable environment. Ames, Iowa: The Iowa State University Press.

Keywords: 43,21,7,18,23,17,29,
THERMAL PROTECTION, GARMENT DESIGN, CHEMICAL RESISTANCE, FLAMMABILITY, HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT), FIREFIGHTERS' PROTECTIVE CLOTHING, MILITARY PROTECTIVE CLOTHING,

(Copy on file)

Abstract:
The text looks at a wide variety of unique apparel items not found collectively in any other work. Its author links functional theory from many fields to clothing design in order to explain how clothing works to protect the human body in a wide range of environments and activities. The text presents basic theory to explain how clothing can provide: protection from extremes of hot and cold; impact protection; protection from radiation, electricity and chemical/biological hazards; freedom of movement; special features such as flotation and high visibility; unique functions through the creative use of fasteners; therapeutic benefits for support and healing. Clothing for astronauts, firefighters, athletes, soldiers, x-ray technicians, surgeons, the handicapped and many others are explained in simple, nonmathematical, language. In addition, sections at the end of each chapter show how to maintain a continual update on functional clothing design developments.

Weidner, V.R. (1971). Spectral reflectance of 11 specimens of firefighters coat fabrics. National Bureau of Standards Report of Text 221.12-11D/71.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Werley, B.L. (Ed.) (1983). *Flammability and Sensitivity of Materials in oxygen-Enriched Atmospheres.*. Philadelphia: ASTM Special Technical Publication STP 812.

Keywords: 18
FLAMMABILITY,

(NO Copy on file)

Abstract:
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Selection of Metals for Gaseous Oxygen Service--Joseph W. Slusser and Keith A. Miller

Werley, B.L. (19xx). Flammability and sensitivity of materials in oxygen-enriched atmospheres. Source unknown.

Keywords: 21,18,29,40,15,31,7
GARMENT DESIGN, FLAMMABILITY, MILITARY PROTECTIVE CLOTHING, TESTING AND TEST METHODS, FABRIC IGNITION TIME, MOLTEN METAL EXPOSURE, CHEMICAL RESISTANCE,

(NO Copy on file)

Abstract:
Contains 11 papers:

Roberta M. Neary
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Coleman J. Bryan
- NASA Mechanical Impact Testing in High-Pressure Oxygen

Richard W. McQuaid, Donald G. Sheets and Mary J. Bieberich
- Determination of Autogenous Ignition Temperatures of a Steam Turbine Lubricating Oil in Nitrogen and Oxygen Mixtures

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Michael A. Benning
- Measurement of Oxygen Index at Elevated Temperatures

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- Heat of Combustion and Oxygen Compatibility

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Rudolf Jenny and Hans R. Wyssmann
- Friction-Induced Ignition in Oxygen

Keith A. Miller
- Selection of Metals for Gaseous Oxygen Service

Whitcomb, M.G. (1969). The wear testing of fabrics. *Modern Textiles Magazine*, (March), 64 - 67.

Keywords: 46,
WEAR STUDY METHODS,

(Copy on file)

Abstract:
- intention is to determine fabrics that are superior to, or at least competitive with, those currently on the market.
- look at: durability = abrasion resistance, rip resistance; performance = shape retention, pill resistance, wrinkle resistance.
- typical wear test compares three or more fabrics after wear to see if one fabric can be considered superior to another

Wien, J.E., Scott, W.D. & Bates, C.E. (1977). Thermal and mechanical properties of aluminized fabrics for use in ferrous metal handling operations. *American Industrial Hygiene Association Journal*, 38, 603 - 612.

Keywords: 23,35,28,43,31,13,2,18,10,14,16,21,8,
HEAT TRANSMISSION (CONDUCTIVE, CONVECTIVE, RADIANT),
PHYSICAL PROPERTIES OF F R FIBERS, METALLIZED FABRICS, THERMAL PROTECTION,
MOLTEN METAL EXPOSURE, F R WOOL (ZIRPRO), ASBESTOS, FLAMMABILITY, COTTON,
FABRIC CONSTRUCTION, FABRIC SYSTEMS, GARMENT DESIGN, CLOTHING SYSTEMS,

(NO Copy on file)

Abstract:

Where there is the possibility of impact by molten metal, heavy, aluminized fabric with a wool, asbestos or some other fabric base is worn in iron and steel plants.

Although it is to provide thermal protection, the garment must be reasonably comfortable, resistant to burning, abrasion resistant, washable and strong.

Fabrics evaluated for tensile strength, tear resistance, abrasion resistance and flame resistance, reflectivity of aluminized fabrics, molten splash resistance.

An FR cotton 'green' cloth, nonaluminized was used as an undergarment in all tests.

Measured properties varied considerably due to weave and fiber. Tensile strength stronger for basket weave than for herringbone but lower abrasion resistance.

Reflectivity - differences in weave and resulting texture of aluminized surface may explain differences. Wear and soiling decreases the reflectivity.

Molten metal protection - heavy rayon basketweave best, cotton, fiberglass, asbestos, other rayons and wool. If weave open, metal may remove the aluminum coating and penetrate, herringbone better than basket or plain for this protection. The felted wool caught fire which consumed both the wool and undergarment. Following heat transfer measurements, aluminized wool may be unsatisfactory for a protective garments while rayon and cotton may be acceptable substitutes for asbestos and may offer increased thermal protection in molten splash situations.

Number of layers is also important. The more layers beneath aluminized fabric the more air is trapped to provide insulation.

Garment construction - any design of seams or garments that allow metal to solidify on the fabric may result in failure and high thermal exposure.

Garment fit should be loose to provide more air insulation.

The smoother the surface of the aluminized cloth, the higher the reflectivity and thus protection from radiant energy.

Yaglov, G.P., & Rao, M.N. (1947). Loose versus close-fitting clothing for work in tropical heat. *Journal of Industrial Hygiene and Toxicology*, 29, 140 - 142.

Keywords:

(Copy NEVER VIEWED)

Abstract:

Yamanathan, N.L. (1964). A new weighting system for mean surface temperature of the human body.. Journal of Applied Physiology, 19(3), 531-533.

Keywords: 40
TESTING AND TEST METHODS,

(Copy on file)

Abstract:

On the basis of an analysis of the skin temperature data on three resting human subjects from 112 experiments, a simple weighting system for computing the mean skin temperature from observations on four areas of the body, namely, chest, arms, thighs, and legs, has been proposed. The proposed system of weighting yields mean skin temperature values identical with the elaborate Hardy-Dubois weighting formula. The value of the medial thigh temperature as an index of the mean skin temperature has also been investigated and discussed.

Wira (1981). Growing interest in 'Survival' textiles. *Textile Digest.*

Keywords: 21,47,41,40,28,29,13,45
GARMENT DESIGN, WEARING COMFORT, THERMAL / HEAT STRESS, TESTING AND TEST METHODS, METALLIZED FABRICS, MILITARY PROTECTIVE CLOTHING, F R WOOL (ZIRPRO), VAPOUR BARRIERS,

(NO Copy on file)

Abstract:
Papers given at the third annual "Design for Survival" conference, held by Wira, covered the following topics with the theme of developments in materials: accurate prediction of fabric performance in adverse weather from laboratory tests; the performance of Meraklon fiber; warmth and comfort of Viloft hollow viscose fiber; the properties of Thinsulate; special properties of metallized surfaces; outdoor garments; military applications of survival wear including bullet-proof vests; the flame retardancy of wool; and microporous GORETEX fabrics.

Woodcock, A.H. (1962). Moisture transfer in textile systems. Part I.. *Textile Research Journal*, 32, 628 - 633.

Keywords: 47,9,24,41,40
WEARING COMFORT, COMFORT ASSESSMENT, INSULATIVE PROPERTIES, THERMAL / HEAT STRESS, TESTING AND TEST METHODS,

(Copy on file)

Abstract:
From theoretical considerations a new clothing parameter, the moisture permeability index, has been developed, which describes the efficiency of fabrics or fabric systems in transferring moisture and its associated latent heat. This index extends the existing "clo" formula, which related dry or nonsweating heat loss to clothing insulation and ambient temperature, to include the heat losses from sweat evaporation. Using this index, it is possible to predict the environmental range over which man may maintain thermal balance with a given heat production or, alternatively, the range of activity and associated heat dissipation for any given environment. It thus supplies not only the missing parameter for quantitatively describing the effect of clothing in hot weather but also permits the same theory to be applied in hot or cold environments.

The experimental method of determining this index is outlined, and typical results are given.

Wight Phillips, A. (1974). Behavioral problems in burn prevention. *Proceedings of: Eighth Annual Meeting of Information Council on Fabric Flammability*, 165 - 172.

Keywords: 3,6
BEHAVIOUR AND ATTITUDES, BURN INJURY,

(Copy on file)

Abstract:
- to teach the principles of fire safety effectively
- reasons for lack of success in past
- we underestimate our chances of being in a fire
- teaching wrong people - aimed at child 6 to 12 years of age when teenagers and adults need education of fire safety.
- discusses arson
- preschool children are particularly vulnerable to clothing fires - should teach them more.

William, H. & Pepler, J.R. (1986). Is there a F.E.A.T. in your future. *Fire Command*, (June), 14 - 17.

Keywords: 3,17
BEHAVIOUR AND ATTITUDES, FIREFIGHTERS' PROTECTIVE CLOTHING,

(Copy on file)

Abstract:
F.E.A.T. - Fire Encounters Acceptance Test
- has photos of the test and what is expected of a fire fighter
- worried about their physical fitness

Williams-Leir, G. (1967). Deaths from clothing and bedding fires. *Canadian Journal of Public Health*, 58, 444.

Keywords:

(Copy NEVER VIEWED)

Abstract:
Not relevant.